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(54) Title: **MYCOBACTERIAL DIAGNOSTICS**

(57) Abstract: The present invention provides nucleic acid molecules unique to *M. paratuberculosis*. The invention also provides the polypeptides encoded by the *M. paratuberculosis*- specific nucleic acid molecules of the invention, and antibodies having specific binding affinity for the polypeptides encoded by the *paratuberculosis*- specific nucleic acid molecules. The invention further provides for methods of detecting *M. paratuberculosis* in a sample using nucleic acid molecules, polypeptides, and antibodies of the invention. The invention additionally provides methods of preventing a *M. paratuberculosis* infection in an animal.

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MYCOBACTERIAL DIAGNOSTICS

INCORPORATION-BY-REFERENCE

5 The material on the accompanying compact disc is hereby incorporated by reference into this application. The accompanying compact disc contains three files, Table8.doc, Table9.doc, and Table10.doc, which were created on March 6, 2003. The file named Table 8.doc is 4.79 MB, the file named Table9.doc is 610 KB, and the file named Table10.doc is 1.61 MB. The files can be accessed using Microsoft Word on a computer that uses Windows OS.

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TECHNICAL FIELD

This invention relates to detection of bacteria, and more particularly to detection of *Mycobacterium avium* subsp. *paratuberculosis*.

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BACKGROUND

The disorder known as Johne's disease was first described in 1895. Today, *Mycobacterium avium* subsp. *paratuberculosis* (*M. paratuberculosis*), the causative agent of Johne's disease, is widely distributed both nationally and internationally in domestic ruminants such as cattle, sheep, goats, as well as wildlife such as rabbits, deer, antelopes, and bison. In 1996, the National Animal Health Monitoring System conducted a survey of dairy farms using serological analysis to determine the prevalence of Johne's disease in the U.S. The results of that study showed an estimated 20-40% of surveyed herds have some level of *M. paratuberculosis*. Furthermore, it is estimated that annual losses in the U.S. from *M. paratuberculosis* in cattle herds may exceed \$220 million.

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The pathogenesis of *M. paratuberculosis* has been recently reviewed by Harris and Barletta (2001, *Clin. Microbiol. Rev.*, 14:489-512). Cattle become infected with *M. paratuberculosis* as calves but often do not develop clinical signs until 2 to 5 years of age. The primary route of infection is through ingestion of fecal material, milk or colostrum containing *M. paratuberculosis* microorganisms. M cells likely serve as the port of entry for *M. paratuberculosis* into the lymphatic system similar to other intracellular pathogens such as salmonella. *M. paratuberculosis* survive and may even replicate within

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macrophages in the wall of the intestine and in regional lymph nodes. After an incubation period of several years, extensive granulomatous inflammation occurs in the terminal small intestine, which leads to malabsorption and protein-losing enteropathy. Cattle shed minimal amounts of *M. paratuberculosis* in their feces during the subclinical phase of infection, and yet over time, this shedding can lead to significant contamination of the environment and an insidious spread of infection throughout the herd before the animal is diagnosed. During the clinical phase of infection, fecal shedding of the pathogen is high and can exceed 10^{10} organisms/g of feces. The terminal clinical stage of disease is characterized by chronic diarrhea, rapid weight loss, diffuse edema, decreased milk production, and infertility. Although transmission of *M. paratuberculosis* occurs primarily through the fecal-oral route, it has also been isolated from reproductive organs of infected males and females.

SUMMARY

The present invention provides nucleic acid molecules unique to *M. paratuberculosis*. The invention also provides polypeptides encoded by the *M. paratuberculosis*-specific nucleic acid molecules of the invention, and antibodies having specific binding affinity for the polypeptides encoded by the *M. paratuberculosis*-specific nucleic acid molecules. The invention further provides for methods of detecting *M. paratuberculosis* in a sample using nucleic acid molecules, polypeptides, or antibodies of the invention. The invention additionally provides for methods of preventing a *M. paratuberculosis* infection in an animal.

In one aspect, the invention provides an isolated nucleic acid, wherein the nucleic acid comprises a nucleic acid molecule of 10 nucleotides to 969 nucleotides, the molecule having at least 75% sequence identity to SEQ ID NO:1 or to the complement of SEQ ID NO:1, wherein any such molecule that is 10 to 35 nucleotides in length, under standard amplification conditions, generates an amplification product from *M. paratuberculosis* nucleic acid using an appropriate second nucleic acid molecule, but does not generate an amplification product from nucleic acid of any of the organisms selected from the group consisting of *Homo sapiens*, *Pseudomonas aeruginosa*, *Streptomyces viridochromogenes*,

Mus musculus, *Felis catus*, and *Xanthomonas campestris* using an appropriate third nucleic acid molecule.

For example, a nucleic acid of the invention can have the sequence shown in SEQ ID NO:1. A nucleic acid of the invention can have at least 75% sequence identity to SEQ ID NO:1 (e.g., SEQ ID NO:102). A nucleic acid of the invention can have at least 80% sequence identity to SEQ ID NO:1 (e.g., SEQ ID NO:103). A nucleic acid of the invention can have at least 85% sequence identity to SEQ ID NO:1 (e.g., SEQ ID NO:104). A nucleic acid of the invention can have at least 90% sequence identity to SEQ ID NO:1 (e.g., SEQ ID NO:105). A nucleic acid of the invention can have at least 95% sequence identity to SEQ ID NO:1 (e.g., SEQ ID NO:106). A nucleic acid of the invention can have at least 99% sequence identity to SEQ ID NO:1 (e.g., SEQ ID NO:107).

In another aspect of the invention, there is provided an isolated nucleic acid, wherein the nucleic acid comprises a nucleic acid molecule of 10 nucleotides to 576 nucleotides, the molecule having at least 75% sequence identity to SEQ ID NO:2 or to the complement of SEQ ID NO:2, wherein any such molecule that is 10 to 35 nucleotides in length, under standard amplification conditions, generates an amplification product from *M. paratuberculosis* nucleic acid using an appropriate second nucleic acid molecule, but does not generate an amplification product from nucleic acid of any of the organisms selected from the group consisting of *Thermotoga* sp., *Homo sapiens*, *Pseudomonas aeruginosa*, *Deinococcus radiodurans*, *Streptomyces coelicolor*, *Oryza sativa*, *Rhizobium leguminosarum*, *Frankia alni*, and *Mesorhizobium loti* using an appropriate third nucleic acid molecule.

In another aspect of the invention, there is provided an isolated nucleic acid, wherein the nucleic acid comprises a nucleic acid molecule of 10 nucleotides to 522 nucleotides, the molecule having at least 75% sequence identity to SEQ ID NO:3 or to the complement of SEQ ID NO:3, wherein any such molecule that is 10 to 35 nucleotides in length, under standard amplification conditions, generates an amplification product from *M. paratuberculosis* nucleic acid using an appropriate second nucleic acid molecule, but does not generate an amplification product from nucleic acid of any of the organisms selected from the group consisting of *Halobacterium* NRC-1, *Oryza sativa*, *Glycine max*,

Streptomyces coelicolor, and *Mus musculus* using an appropriate third nucleic acid molecule.

In another aspect of the invention, there is provided an isolated nucleic acid, wherein the nucleic acid comprises a nucleic acid molecule of 10 nucleotides to 582
5 nucleotides, the molecule having at least 75% sequence identity to SEQ ID NO:4 or to the complement of SEQ ID NO:4, wherein any such molecule that is 10 to 47 nucleotides in length, under standard amplification conditions, generates an amplification product from *M. paratuberculosis* nucleic acid using an appropriate second nucleic acid molecule, but does not generate an amplification product from nucleic acid of any of the organisms
10 selected from the group consisting of *Oryza sativa*, *Caenorhabditis elegans*, *Leishmania mexicana*, *Drosophila melanogaster*, *Homo sapiens*, *Zea mays*, *Halobacterium* sp. NRC-1, *Pseudomonas aeruginosa*, *Ralstonia solanacearum*, and *Streptomyces coelicolor* using an appropriate third nucleic acid molecule.

In another aspect of the invention, there is provided an isolated nucleic acid,
15 wherein the nucleic acid comprises a nucleic acid molecule of 10 nucleotides to 311 nucleotides, the molecule having at least 75% sequence identity to SEQ ID NO:5 or to the complement of SEQ ID NO:5, wherein any such molecule that is 10 to 36 nucleotides in length, under standard amplification conditions, generates an amplification product from *M. paratuberculosis* nucleic acid using an appropriate second nucleic acid molecule, but
20 does not generate an amplification product from nucleic acid of any of the organisms selected from the group consisting of *Homo sapiens*, *Streptomyces coelicolor*, *Ictalurid herpesvirus*, *Mesorhizobium loti*, and *Oryza sativa* using an appropriate third nucleic acid molecule.

In another aspect of the invention, there is provided an isolated nucleic acid,
25 wherein the nucleic acid comprises a nucleic acid molecule of 10 nucleotides to 576 nucleotides, the molecule having at least 75% sequence identity to SEQ ID NO:6 or to the complement of SEQ ID NO:6, wherein any such molecule that is 10 to 41 nucleotides in length, under standard amplification conditions, generates an amplification product from *M. paratuberculosis* nucleic acid using an appropriate second nucleic acid molecule, but
30 does not generate an amplification product from nucleic acid of any of the organisms selected from the group consisting of *Pseudomonas aeruginosa*, *Ralstonia solanacearum*,

Arabidopsis thaliana, *Pseudomonas fluorescens*, *Homo sapiens*, and *Mesorhizobium loti* using an appropriate third nucleic acid molecule.

In another aspect of the invention, there is provided an isolated nucleic acid, wherein the nucleic acid comprises a nucleic acid molecule of 10 nucleotides to 474
5 nucleotides, the molecule having at least 75% sequence identity to SEQ ID NO:7 or to the complement of SEQ ID NO:7, wherein any such molecule that is 10 to 35 nucleotides in length, under standard amplification conditions, generates an amplification product from *M. paratuberculosis* nucleic acid using an appropriate second nucleic acid molecule, but does not generate an amplification product from nucleic acid of any of the organisms
10 selected from the group consisting of *Homo sapiens*, *Pantoea agglomerans*, *Rattus norvegicus*, *Erwinia uredovora*, *Erwinia ananas*, and *Pantoea ananatis* using an appropriate third nucleic acid molecule.

In another aspect of the invention, there is provided an isolated nucleic acid, wherein the nucleic acid comprises a nucleic acid molecule of 10 nucleotides to 558
15 nucleotides, the molecule having at least 75% sequence identity to SEQ ID NO:8 or to the complement of SEQ ID NO:8, wherein any such molecule that is 10 to 36 nucleotides in length, under standard amplification conditions, generates an amplification product from *M. paratuberculosis* nucleic acid using an appropriate second nucleic acid molecule, but does not generate an amplification product from nucleic acid of any of the organisms
20 selected from the group consisting of *Neisseria meningitidis*, *Homo sapiens*, *Streptomyces coelicolor*, *Arabidopsis thaliana*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Streptomyces hygroscopicus* var. *ascomyceticus*, *Ralstonia solanacearum*, *Deinococcus radiodurans*, *Rhizobium meliloti*, *Rickettsia typhi*, *Streptomyces* sp., and *Mus musculus* using an appropriate third nucleic acid molecule.

25 In another aspect of the invention, there is provided an isolated nucleic acid, wherein the nucleic acid comprises a nucleic acid molecule of 10 nucleotides to 321 nucleotides, the molecule having at least 75% sequence identity to SEQ ID NO:9 or to the complement of SEQ ID NO:9, wherein any such molecule that is 10 to 36 nucleotides in length, under standard amplification conditions, generates an amplification product from
30 *M. paratuberculosis* nucleic acid using an appropriate second nucleic acid molecule, but does not generate an amplification product from nucleic acid of any of the organisms

selected from the group consisting of *Mycobacterium tuberculosis*, *Homo sapiens*, *Streptomyces coelicolor*, *Drosophila melanogaster*, *Ralstonia solanacearum*, *Mesorhizobium loti*, and *Pseudomonas cruciviae* using an appropriate third nucleic acid molecule.

5 In another aspect of the invention, there is provided an isolated nucleic acid, wherein the nucleic acid comprises a nucleic acid molecule of 10 nucleotides to 2508 nucleotides, the molecule having at least 75% sequence identity to SEQ ID NO:10 or to the complement of SEQ ID NO:10, wherein any such molecule that is 10 to 44 nucleotides in length, under standard amplification conditions, generates an amplification
10 product from *M. paratuberculosis* nucleic acid using an appropriate second nucleic acid molecule, but does not generate an amplification product from nucleic acid of any of the organisms selected from the group consisting of *Sinorhizobium meliloti*, *Xanthomonas albilineans*, *Halobacterium* sp. NRC-1, *Ralstonia solanacearum*, *Deinococcus radiodurans*, *Halobacterium salinarum*, *Micromonospora griseorubida*, *Pseudomonas paucimobilis*, and *Streptomyces lividans* using an appropriate third nucleic acid molecule.
15

 In another aspect of the invention, there is provided an isolated nucleic acid, wherein the nucleic acid comprises a nucleic acid molecule of 10 nucleotides to 264 nucleotides, the molecule having at least 75% sequence identity to SEQ ID NO:11 or to the complement of SEQ ID NO:11, wherein any such molecule that is 10 to 36
20 nucleotides in length, under standard amplification conditions, generates an amplification product from *M. paratuberculosis* nucleic acid using an appropriate second nucleic acid molecule, but does not generate an amplification product from nucleic acid of any of the organisms selected from the group consisting of *Caulobacter crescentus*, *Brucella melitensis*, *Pyrobaculum aerophilum*, *Mycobacterium tuberculosis*, *Sinorhizobium meliloti*, and *Mycobacterium leprae* using an appropriate third nucleic acid molecule.
25

 In another aspect of the invention, there is provided an isolated nucleic acid, wherein the nucleic acid comprises a nucleic acid molecule of 10 nucleotides to 1110 nucleotides, the molecule having at least 75% sequence identity to SEQ ID NO:12 or to the complement of SEQ ID NO:12, wherein any such molecule that is 10 to 39
30 nucleotides in length, under standard amplification conditions, generates an amplification product from *M. paratuberculosis* nucleic acid using an appropriate second nucleic acid

molecule, but does not generate an amplification product from nucleic acid of any of the organisms selected from the group consisting of *Mesorhizobium loti*, *Bacillus halodurans*, *Ralstonia solanacearum*, *Homo sapiens*, *Drosophila melanogaster*, and *Rhizobium meliloti* using an appropriate third nucleic acid molecule.

5 In another aspect of the invention, there is provided an isolated nucleic acid, wherein the nucleic acid comprises a nucleic acid molecule of 10 nucleotides to 672 nucleotides, the molecule having at least 75% sequence identity to SEQ ID NO:13 or to the complement of SEQ ID NO:13, wherein any such molecule that is 10 to 30 nucleotides in length, under standard amplification conditions, generates an amplification
10 product from *M. paratuberculosis* nucleic acid using an appropriate second nucleic acid molecule, but does not generate an amplification product from nucleic acid of *M. avium* subsp. *avium* using an appropriate third nucleic acid molecule.

 In another aspect of the invention, there is provided an isolated nucleic acid, wherein the nucleic acid comprises a nucleic acid molecule of 10 nucleotides to 372
15 nucleotides, the molecule having at least 75% sequence identity to SEQ ID NO:14 or to the complement of SEQ ID NO:14, wherein any such molecule that is 10 to 30 nucleotides in length, under standard amplification conditions, generates an amplification product from *M. paratuberculosis* nucleic acid using an appropriate second nucleic acid molecule, but does not generate an amplification product from nucleic acid of any of the
20 organisms selected from the group consisting of *Brucella melitensis*, *Streptomyces coelicolor*, *Drosophila melanogaster*, *Mycobacterium tuberculosis*, *Trypanosoma rangeli*, *Trypanosoma minasense*, *Trypanosoma leeuwenhoekii*, and *Brassica napus* using an appropriate third nucleic acid molecule.

 In another aspect of the invention, there is provided an isolated nucleic acid,
25 wherein the nucleic acid comprises a nucleic acid molecule of 10 nucleotides to 600 nucleotides, the molecule having at least 75% sequence identity to SEQ ID NO:15 or to the complement of SEQ ID NO:15, wherein any such molecule that is 10 to 35 nucleotides in length, under standard amplification conditions, generates an amplification product from *M. paratuberculosis* nucleic acid using an appropriate second nucleic acid
30 molecule, but does not generate an amplification product from nucleic acid of any of the organisms selected from the group consisting of *Ralstonia solanacearum*, *Sinorhizobium*

meliloti, *Homo sapiens*, *Mesorhizobium loti*, *Oryza sativa*, *Drosophila melanogaster*, *Rhizobium leguminosarum*, *Xylella fastidiosa*, *Deinococcus radiodurans*, *Achromobacter cycloclastes*, and *Candida cylindracea* using an appropriate third nucleic acid molecule.

In another aspect of the invention, there is provided an isolated nucleic acid,
5 wherein the nucleic acid comprises a nucleic acid molecule of 10 nucleotides to 540 nucleotides, the molecule having at least 75% sequence identity to SEQ ID NO:16 or to the complement of SEQ ID NO:16, wherein any such molecule that is 10 to 45 nucleotides in length, under standard amplification conditions, generates an amplification product from *M. paratuberculosis* nucleic acid using an appropriate second nucleic acid
10 molecule, but does not generate an amplification product from nucleic acid of any of the organisms selected from the group consisting of *Streptomyces lavendulae*, *Xylella fastidiosa*, *Streptococcus pneumoniae*, *Mycobacterium tuberculosis*, *Pseudomonas aeruginosa*, *Ralstonia solanacearum*, *Sinorhizobium meliloti*, *Sus scrofa*, *Mycobacterium leprae*, and *Streptomyces coelicolor* using an appropriate third nucleic acid molecule.

15 In another aspect of the invention, there is provided an isolated nucleic acid, wherein the nucleic acid comprises a nucleic acid molecule of 10 nucleotides to 291 nucleotides, the molecule having at least 75% sequence identity to SEQ ID NO:17 or to the complement of SEQ ID NO:17, wherein any such molecule that is 10 to 37 nucleotides in length, under standard amplification conditions, generates an amplification
20 product from *M. paratuberculosis* nucleic acid using an appropriate second nucleic acid molecule, but does not generate an amplification product from nucleic acid of any of the organisms selected from the group consisting of *Pseudomonas sp.*, *Homo sapiens*, *Pseudomonas aeruginosa*, *Thauera aromatica*, *Oryza sativa*, *Ralstonia solanacearum*, *Rhizobium leguminosarum*, *Streptomyces coelicolor*, *Brucella melitensis*, *Drosophila*
25 *melanogaster*, *Deinococcus radiodurans*, *Streptomyces noursei*, *Rhizobium meliloti*, *Synechococcus elongates*, *Sinorhizobium meliloti*, and *Mesorhizobium loti* using an appropriate third nucleic acid molecule.

In another aspect of the invention, there is provided an isolated nucleic acid, wherein the nucleic acid comprises a nucleic acid molecule of 10 nucleotides to 225
30 nucleotides, the molecule having at least 75% sequence identity to SEQ ID NO:18 or to the complement of SEQ ID NO:18, wherein any such molecule that is 10 to 37

nucleotides in length, under standard amplification conditions, generates an amplification product from *M. paratuberculosis* nucleic acid using an appropriate second nucleic acid molecule, but does not generate an amplification product from nucleic acid of any of the organisms selected from the group consisting of *Rhodobacter capsulatus*, *Agrobacterium tumefaciens*, *Mycobacterium smegmatis*, *Pseudomonas aeruginosa*, *Ralstonia solanacearum*, and *Drosophila virilis* using an appropriate third nucleic acid molecule.

In another aspect of the invention, there is provided an isolated nucleic acid, wherein the nucleic acid comprises a nucleic acid molecule of 10 nucleotides to 441 nucleotides, the molecule having at least 75% sequence identity to SEQ ID NO:19 or to the complement of SEQ ID NO:19, wherein any such molecule that is 10 to 30 nucleotides in length, under standard amplification conditions, generates an amplification product from *M. paratuberculosis* nucleic acid using an appropriate second nucleic acid molecule, but does not generate an amplification product from nucleic acid of any of the organisms selected from the group consisting of *Homo sapiens*, *Mus musculus*, *Leishmania major*, *Pseudomonas aeruginosa*, and *Botrytis cinerea* using an appropriate third nucleic acid molecule.

In another aspect of the invention, there is provided an isolated nucleic acid, wherein the nucleic acid comprises a nucleic acid molecule of 10 nucleotides to 726 nucleotides, the molecule having at least 75% sequence identity to SEQ ID NO:20 or to the complement of SEQ ID NO:20, wherein any such molecule that is 10 to 41 nucleotides in length, under standard amplification conditions, generates an amplification product from *M. paratuberculosis* nucleic acid using an appropriate second nucleic acid molecule, but does not generate an amplification product from nucleic acid of any of the organisms selected from the group consisting of *Oryza sativa*, *Caulobacter crescentus*, *Rhodobacter sphaeroides*, *Streptomyces coelicolor*, *Spermatozopsis similis*, *Homo sapiens*, *Sus scrofa*, and *Giardia intestinalis* using an appropriate third nucleic acid molecule.

In another aspect of the invention, there is provided an isolated nucleic acid, wherein the nucleic acid comprises a nucleic acid molecule of 10 nucleotides to 426 nucleotides, the molecule having at least 75% sequence identity to SEQ ID NO:21 or to the complement of SEQ ID NO:21, wherein any such molecule that is 10 to 44

nucleotides in length, under standard amplification conditions, generates an amplification product from *M. paratuberculosis* nucleic acid using an appropriate second nucleic acid molecule, but does not generate an amplification product from nucleic acid of any of the organisms selected from the group consisting of *Streptomyces coelicolor*, *Homo sapiens*,
 5 *Triticum aestivum*, *Oryza sativa*, *Brucella melitensis*, *Caulobacter crescentus*,
Pseudomonas aeruginosa, *Ralstonia solanacearum*, *Bovine herpesvirus*, and
Mesorhizobium loti using an appropriate third nucleic acid molecule.

In another aspect of the invention, there is provided an isolated nucleic acid, wherein the nucleic acid comprises a nucleic acid molecule of 10 nucleotides to 279
 10 nucleotides, the molecule having at least 75% sequence identity to SEQ ID NO:22 or to the complement of SEQ ID NO:22, wherein any such molecule that is 10 to 45 nucleotides in length, under standard amplification conditions, generates an amplification product from *M. paratuberculosis* nucleic acid using an appropriate second nucleic acid molecule, but does not generate an amplification product from nucleic acid of any of the
 15 organisms selected from the group consisting of *Pseudomonas aeruginosa*, *Oryza sativa*, *Streptomyces sp.*, *Streptomyces peucetius*, *Rhizobium sp.*, *Mycobacterium tuberculosis*, *Caulobacter crescentus*, *Ralstonia solanacearum*, *Haloferax volcanii*, *Mycobacterium leprae*, and *Streptomyces coelicolor* using an appropriate third nucleic acid molecule.

In another aspect of the invention, there is provided an isolated nucleic acid,
 20 wherein the nucleic acid comprises a nucleic acid molecule of 10 nucleotides to 4415 nucleotides, the molecule having at least 75% sequence identity to SEQ ID NO:23 or to the complement of SEQ ID NO:23, wherein any such molecule that is 10 to 50 nucleotides in length, under standard amplification conditions, generates an amplification product from *M. paratuberculosis* nucleic acid using an appropriate second nucleic acid
 25 molecule, but does not generate an amplification product from nucleic acid of any of the organisms selected from the group consisting of *Ralstonia solanacearum*, *Sinorhizobium meliloti*, *Homo sapiens*, *Mesorhizobium loti*, *Oryza sativa*, *Drosophila melanogaster*, *Rhizobium leguminosarum*, *Xylella fastidiosa*, *Deinococcus radiodurans*, *Achromobacter cycloclastes*, *Candida cylindracea*, *Streptomyces lavendulae*, *Streptococcus pneumoniae*,
 30 *Mycobacterium tuberculosis*, *Pseudomonas aeruginosa*, *Sus scrofa*, *Mycobacterium leprae*, *Streptomyces coelicolor*, *Pseudomonas sp.*, *Thauera aromatica*, *Brucella*

melitensis, *Streptomyces noursei*, *Rhizobium meliloti*, *Synechococcus elongates*,
Rhodobacter capsulatus, *Agrobacterium tumefaciens*, *Mycobacterium smegmatis*,
Drosophila virilis, *Mus musculus*, *Leishmania major*, *Botrytis cinerea*, *Caulobacter*
crescentus, *Rhodobacter sphaeroides*, *Spermatozopsis similes*, *Giardia intestinalis*,
5 *Triticum aestivum*, *Bovine herpesvirus*, *Streptomyces sp.*, *Streptomyces peucetius*,
Rhizobium sp., and *Haloferax volcanii* using an appropriate third nucleic acid molecule.

Generally, the invention provides an isolated nucleic acid, wherein the nucleic acid comprises a nucleic acid molecule of at least 10 nucleotides, the molecule having at least 75% sequence identity to a sequence selected from the group consisting of SEQ ID
10 NOs:1-23 or to the complement of a sequence selected from the group consisting of SEQ ID NOs:1-23, wherein any such molecule that is 10 to 30 nucleotides in length, under standard amplification conditions, generates an amplification product from *M. paratuberculosis* nucleic acid using an appropriate second nucleic acid molecule, but does not generate an amplification product from nucleic acid of any of the organisms selected
15 from the group consisting of *Ralstonia solanacearum*, *Sinorhizobium meliloti*, *Homo sapiens*, *Mesorhizobium loti*, *Oryza sativa*, *Drosophila melanogaster*, *Rhizobium leguminosarum*, *Xylella fastidiosa*, *Deinococcus radiodurans*, *Achromobacter cycloclastes*, *Candida cylindracea*, *Streptomyces lavendulae*, *Streptococcus pneumoniae*, *Mycobacterium tuberculosis*, *Pseudomonas aeruginosa*, *Sus scrofa*, *Mycobacterium leprae*,
20 *Streptomyces coelicolor*, *Pseudomonas sp.*, *Thauera aromatica*, *Brucella melitensis*, *Streptomyces noursei*, *Rhizobium meliloti*, *Synechococcus elongates*, *Rhodobacter capsulatus*, *Agrobacterium tumefaciens*, *Mycobacterium smegmatis*, *Drosophila virilis*, *Mus musculus*, *Leishmania major*, *Botrytis cinerea*, *Caulobacter crescentus*, *Rhodobacter sphaeroides*, *Spermatozopsis similes*, *Giardia intestinalis*,
25 *Triticum aestivum*, *Bovine herpesvirus*, *Streptomyces sp.*, *Streptomyces peucetius*, *Rhizobium sp.*, *Haloferax volcanii*, *Streptomyces viridochromogenes*, *Felis catus*, *Xanthomonas campestris*, *Thermotoga maritime*, *Thermotoga neapolitana*, *Frankia alni*, *Halobacterium NRC-1*, *Glycine max*, *Leishmania tarentolae*, *Neisseria meningitides*, *Escherichia coli*, *Caenorhabditis elegans*, *Leishmania mexicana*, *Zea mays*, *Ictalurid herpesvirus*,
30 *Rattus norvegicus*, *Arabidopsis thaliana*, *Pseudomonas fluorescens*, *Pantoea agglomerans*, *Erwinia uredovora*, *Pantoea ananatis*, *Streptomyces hygroscopicus*,

Rickettsia typhi, *Pseudomonas cruciviae*, *Xanthomonas albilineans*, *Halobacterium salinarium*, *Micromonospora griseorubida*, *Pseudomonas paucimobilis*, *Streptomyces lividans*, *Pyrobaculum aerophilum*, *Sinorhizobium meliloti*, *Mesorhizobium loti*, *Bacillus halodurans*, *Trypanosoma rangeli*, *Trypanosoma minasense*, *Trypanosoma leeuwenhoekii*,
 5 and *Brassica napus* using an appropriate third nucleic acid molecule.

The invention provides for an isolated nucleic acid comprising a nucleic acid molecule of 10 nucleotides to 200 nucleotides having at least 75% sequence identity to one of the sequences set out in SEQ ID NOs:110-1342 or to the complement of that sequence. Using Table 1 as a reference, any such molecule that is 10 to N nucleotides in
 10 length, under standard amplification conditions, generates an amplification product from *M. paratuberculosis* nucleic acid using an appropriate second nucleic acid molecule, but does not generate an amplification product from nucleic acid of any of the organisms shown in Table 1 corresponding to the respective SEQ ID NO, using an appropriate third
 15 nucleic acid molecule. For example, for SEQ ID NO:110 (segment 26), any such molecule that is 10 to 33 nucleotides in length, under standard amplification conditions, generates an amplification product from *M. paratuberculosis* nucleic acid using an appropriate second nucleic acid molecule, but does not generate an amplification product from nucleic acid of *Mus musculus* and *Rhodobacter sphaeroides*, using an appropriate third
 20 nucleic acid molecule.

Table 1.

Fragment Designation	SEQ ID NO:	N (nt)	Organisms
26	110	33	<i>Mus musculus</i> ; <i>Rhodobacter sphaeroides</i>
27	111	38	<i>Novosphingobium aromaticivorans</i> ; <i>Corynebacterium efficiens</i>
28	112	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
29	113	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
30	114	32	<i>Brucella melitensis</i> ; <i>Brucella suis</i>
31	115	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
32	116	32	<i>Galleria mellonella</i>
33	117	32	<i>Oryctolagus cuniculus</i> ; <i>Novosphingobium aromaticivorans</i>
35	118	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
36	119	38	<i>Oryza sativa</i> ; <i>Burkholderia fungorum</i>
37	120	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
38	121	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
39	122	39	<i>Magnetospirillum magnetotacticum</i> ; <i>Zea mays</i> ; <i>Oryza</i>

			<i>sativa; Streptomyces coelicolor</i>
40	123	32	<i>Neurospora crassa</i>
41	124	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
47	125	33	<i>Ralstonia solanacearum</i>
48	126	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
56	127	42	<i>Halobacterium</i> sp. NRC-1; <i>Oryza sativa</i>
57	128	32	<i>Mus musculus; Arabidopsis thaliana</i>
58	129	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
59	130	38	<i>Ralstonia metallidurans; Magnetospirillum magnetotacticum</i>
60	131	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
61	132	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
62	133	36	<i>Ralstonia metallidurans</i>
63	134	38	<i>Leishmania donovani; Oryza sativa</i>
67	135	32	<i>Oryza sativa</i>
68	136	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
69	137	33	<i>Mus musculus; Archaeoglobus fulgidus</i>
70	138	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
71	139	32	<i>Corynebacterium efficiens</i>
72	140	45	<i>Pseudomonas aeruginosa</i>
73	141	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
74	142	41	<i>Rhodospirillum rubrum; Ralstonia eutropha</i>
75	143	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
76	144	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
77	145	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
79	146	32	<i>Actinosynnema pretiosum</i> subsp. <i>auranticum maytansino</i>
80	147	44	<i>Streptomyces coelicolor; Homo sapiens; Rhodopseudomonas palustris; Triticum aestivum</i>
81	148	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
82	149	41	<i>Oryza sativa; Spermatozopsis similis</i>
83	150	32	<i>Streptomyces coelicolor</i>
85	151	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
86	152	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
87	153	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
88	154	32	<i>Ralstonia solanacearum</i>
89	155	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
90	156	33	<i>Pseudomonas</i> sp.; <i>Chlorobium tepidum; Pseudomonas aeruginosa</i>
91	157	38	<i>Homo sapiens; Lentinus edodes; Geobacter metallireducens; Thauera aromatica; Oryza sativa</i>
92	158	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
93	159	32	<i>Chlamydomonas geitleri</i>
94	160	45	<i>Streptomyces lavendulae</i>
95	161	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
96	162	32	<i>Xanthomonas campestris; Xanthomonas axonopodis</i>
97	163	32	<i>Homo sapiens</i>
98	164	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
99	165	32	<i>Ralstonia solanacearum</i>
100	166	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>

101	167	47	<i>Mus musculus</i> ; <i>Mycobacterium avium</i> ; <i>Homo sapiens</i> ; <i>Pseudomonas pseudoalcaligenes</i>
102	168	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
103	169	32	<i>Oryctolagus cuniculus</i>
104	170	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
105	171	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
106	172	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
107	173	38	<i>Corynebacterium efficiens</i>
108	174	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
109	175	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
110	176	33	<i>Homo sapiens</i>
112	177	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
236	178	56	<i>Mycobacterium tuberculosis</i> ; Shrimp white spot syndrome virus; <i>Mus</i> sp.; <i>Rattus norvegicus</i> ; <i>Drosophila melanogaster</i> ; <i>Eimeria tenella</i> ; <i>Chlamydomonas reinhardtii</i> ; <i>Bos taurus</i> ; <i>Saccharomyces cerevisiae</i> ; <i>Homo sapiens</i> ; <i>Gallus gallus</i>
257	179	50	<i>Mycobacterium tuberculosis</i> ; <i>Oryza sativa</i> ; <i>Azotobacter vinelandii</i> ; <i>Pseudorabies virus</i> ; <i>Homo sapiens</i> ; <i>Mus musculus</i> ; <i>Desulfitobacterium hafniense</i> ; <i>Triticum aestivum</i> ; <i>Streptomyces coelicolor</i>
280	180	45	<i>Mycobacterium tuberculosis</i> ; <i>Oryza sativa</i> ; <i>Rhodobacter sphaeroides</i> ; <i>Burkholderia fungorum</i> ; <i>Desulfitobacterium hafniense</i>
330	181	74	<i>Mycobacterium tuberculosis</i>
354	182	116	<i>Mycobacterium tuberculosis</i> ; <i>Rhodococcus fascians</i> ; <i>Magnetospirillum magnetotacticum</i> ; <i>Mycobacterium leprae</i> ; <i>Deinococcus radiodurans</i> ; <i>Xanthomonas campestris</i> ; <i>Homo sapiens</i> ; <i>Rhodospirillum rubrum</i> ; <i>Oryza sativa</i> ; <i>Streptomyces coelicolor</i> ; <i>Penaeus vannamei</i> ; <i>Mus musculus</i> ; <i>Caulobacter crescentus</i>
518	183	102	<i>Mycobacterium tuberculosis</i> ; <i>Mycobacterium leprae</i> ; <i>Rhodobacter sphaeroides</i> ; <i>Rhodospirillum rubrum</i> ; <i>Burkholderia fungorum</i> ; <i>Xanthomonas oryzae</i>
584	184	66	<i>Mycobacterium tuberculosis</i> ; <i>Ralstonia metallidurans</i> ; <i>Homo sapiens</i> ; <i>Azotobacter vinelandii</i>
585	185	95	<i>Mesorhizobium loti</i>
586	186	45	<i>Sinorhizobium meliloti</i> ; <i>Xanthomonas campestris</i> ; <i>Rhodopseudomonas palustris</i> ; <i>Actinomyces naeslundii</i> ; <i>Streptomyces coelicolor</i>
587	187	45	<i>Pseudomonas fluorescens</i> ; <i>Mesorhizobium loti</i> ; <i>Azotobacter vinelandii</i> ; <i>Streptomyces coelicolor</i> ; <i>Oryza sativa</i> ; <i>Macaca mulatta rhadinovirus</i> ; <i>Pseudomonas aeruginosa</i>
588	188	42	<i>Rhodobacter sphaeroides</i> ; <i>Halobacterium</i> sp. NRC-1;
589	189	70	<i>Mycobacterium leprae</i>
609	190	44	<i>Magnetospirillum magnetotacticum</i> ; <i>Rhodopseudomonas palustris</i> ; <i>Homo sapiens</i> ; <i>Amycolatopsis mediterranei</i> ; <i>Streptomyces coelicolor</i>

744	191	44	<i>Oryza sativa</i> ; <i>Homo sapiens</i> ; <i>Mus musculus</i>
811	192	99	<i>Mycobacterium tuberculosis</i> ; <i>Hordeum vulgare</i> ; <i>Streptomyces coelicolor</i> ; <i>Oryza sativa</i> ; <i>Desulfotobacterium hafniense</i> ; <i>Haloferax mediterranei</i> ; <i>Pseudomonas aeruginosa</i> ; <i>Mus musculus</i> ; <i>Haloferax volcanii</i> ; <i>Homo sapiens</i> ; <i>Pseudomonas fluorescens</i> ; <i>Azotobacter vinelandii</i> ; <i>Sorghum vulgare</i> ; <i>Zea mays</i>
813	193	38	<i>Ralstonia metallidurans</i> ; <i>Frankia</i> sp.; <i>Homo sapiens</i> ; <i>Streptomyces coelicolor</i> ; <i>Oryza sativa</i>
935	194	66	<i>Mycobacterium tuberculosis</i> ; <i>Mycobacterium phage</i> Ms6; <i>Ralstonia solanacearum</i> ; <i>Oryza sativa</i> ; <i>Rhodobacter sphaeroides</i> ; <i>Rhodopseudomonas palustris</i> ; <i>Caulobacter crescentus</i> ; <i>Actinosynnema pretiosum</i> ; <i>Homo sapiens</i> ; <i>Thermobifida fusca</i> ; <i>Streptomyces noursei</i> ; <i>Mesorhizobium loti</i> ; <i>Bifidobacterium longum</i> ; <i>Streptomyces coelicolor</i>
1001	195	86	<i>Mycobacterium tuberculosis</i> ; <i>Pseudomonas fluorescens</i> ; <i>Rhodospirillum rubrum</i> ; <i>Ralstonia solanacearum</i> ; <i>Amycolatopsis orientalis</i> ; <i>Pseudomonas syringae</i> ; <i>Desulfotobacterium hafniense</i> ; <i>Deinococcus radiodurans</i> ; <i>Myxococcus xanthus</i>
1007	196	135	<i>Mycobacterium tuberculosis</i> ; <i>Streptomyces coelicolor</i>
1027	197	45	<i>Ralstonia metallidurans</i> ; <i>Azorhizobium caulinodans</i> ; <i>Pseudomonas aeruginosa</i> ; <i>Canis familiaris</i> ; <i>Sus scrofa</i> ; <i>Neurospora crassa</i> ; <i>Rhodobacter sphaeroides</i> ; <i>Rhodospirillum rubrum</i> ; <i>Oryza sativa</i> ; <i>Streptomyces coelicolor</i> ; <i>Caulobacter crescentus</i> ; <i>Papio anubis</i>
1104	198	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
1105	199	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
1106	200	32	<i>Rhizobium meliloti</i> ; <i>Sinorhizobium meliloti</i>
1107	201	32	<i>Nocardioide</i> sp.; <i>Thermobifida fusca</i>
1108	202	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
1109	203	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
1110	204	35	<i>Desulfovibrio desulfuricans</i> ; <i>Drosophila melanogaster</i>
1111	205	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
1112	206	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
1113	207	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
1114	208	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
1115	209	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
1116	210	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
1117	211	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
1118	212	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
1119	213	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
1120	214	32	<i>Drosophila melanogaster</i>
1121	215	39	<i>Cordyceps pseudomilitaris</i> ; <i>Oryza sativa</i>
1122	216	35	<i>Pseudomonas aeruginosa</i>
1123	217	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
1130	218	44	<i>Mycobacterium tuberculosis</i> ; <i>Oryza sativa</i> ; <i>Magnetospirillum magnetotacticum</i> ; <i>Sinorhizobium meliloti</i> ; <i>Burkholderia fungorum</i> ; <i>Caulobacter crescentus</i> ;

			<i>Ralstonia metallidurans</i> ; <i>Rhodobacter capsulatus</i> ; <i>Corynebacterium efficiens</i> ; <i>Homo sapiens</i> ; <i>Mus musculus</i>
1549	219	98	<i>Mycobacterium leprae</i> ; <i>Mycobacterium tuberculosis</i> ; <i>Oryza sativa</i> ; <i>Xanthomonas axonopodis</i>
1733	220	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
1735	221	33	<i>Homo sapiens</i> ; <i>Escherichia coli</i>
1873	222	105	<i>Mycobacterium tuberculosis</i> ; <i>Streptomyces coelicolor</i> ; <i>Oryza sativa</i> ; <i>Pseudomonas aeruginosa</i> ; <i>Micromonospora</i> <i>chersonia</i> ; <i>Halobacterium</i> sp. NRC-1; <i>Homo sapiens</i> <i>Deinococcus radiodurans</i> ; <i>Zea mays</i>
1904	223	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
1905	224	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
1906	225	38	<i>Burkholderia fungorum</i>
2459	226	39	<i>Magnetospirillum magnetotacticum</i> ; <i>Mesorhizobium loti</i> ; <i>Propionibacterium freudenreichii</i> ; <i>Streptomyces</i> <i>coelicolor</i> ; <i>Xanthomonas campestris</i>
2476	227	51	<i>Mycobacterium tuberculosis</i> ; <i>Streptomyces coelicolor</i> ; <i>Oryza sativa</i> ; <i>Homo sapiens</i> ; <i>Spodoptera frugiperda</i> ; <i>Rhodospirillum rubrum</i> ; <i>Thermobifida fusca</i> ; <i>Streptomyces</i> <i>lividans</i> ; <i>Corynebacterium efficiens</i>
2634	228	78	<i>Mycobacterium kansasii</i> ; <i>Burkholderia fungorum</i> ; <i>Ralstonia solanacearum</i> ; <i>Halobacterium</i> sp.; <i>Sinorhizobium meliloti</i>
2842	229	44	<i>Gallus gallus</i> ; <i>Ralstonia solanacearum</i> ; <i>Mycobacterium</i> <i>avium</i> ; <i>Streptomyces avermitilis</i> ; <i>Streptomyces</i> sp.
2863	230	32	<i>Thermobifida fusca</i>
2865	231	77	<i>Mycobacterium tuberculosis</i> ; <i>Streptomyces coelicolor</i> ; <i>Micromonospora megalomicea</i> subsp. <i>nigra megalomicin</i>
2932	232	80	<i>Mycobacterium leprae</i> ; <i>Mycobacterium tuberculosis</i> ; <i>Amycolatopsis</i> sp.; <i>Oryza sativa</i> ; <i>Ralstonia solanacearum</i> ; <i>Streptomyces coelicolor</i>
3034	233	32	<i>Mycobacterium leprae</i> ; <i>Corynebacterium efficiens</i> ; <i>Oryza</i> <i>sativa</i>
3156	234	32	<i>Mus musculus</i>
3254	235	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
3255	236	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
3256	237	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
3257	238	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
3258	239	32	<i>Mesorhizobium loti</i> ; <i>Ralstonia solanacearum</i>
3260	240	33	<i>Mesorhizobium loti</i>
3261	241	39	<i>Bacillus halodurans</i>
3262	242	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
3358	243	74	<i>Mycobacterium tuberculosis</i> ; <i>Mycobacterium leprae</i> ; <i>Oryza sativa</i> ; <i>Desulfotobacterium hafniense</i> ; <i>Xanthomonas</i> <i>campestris</i> ; <i>Bovine herpesvirus</i> ; <i>Rhodopseudomonas</i> <i>palustris</i> ; <i>Magnetospirillum magnetotacticum</i>
3614	244	45	<i>Homo sapiens</i> ; <i>Klebsiella aerogenes</i> ; <i>Enterobacter</i> <i>aerogenes</i> ; <i>Pseudomonas</i> sp.; <i>Ralstonia metallidurans</i> ; <i>Magnetospirillum magnetotacticum</i> ; <i>Streptomyces</i>

			<i>coelicolor</i> ; <i>Pseudomonas putida</i> ; <i>Bos taurus</i> ; <i>Rhodobacter sphaeroides</i> ; <i>Mus musculus</i>
3681	245	45	<i>Neurospora crassa</i> ; <i>Streptomyces avermitilis</i> ; <i>Rubrivivax gelatinosus</i> ; <i>Pseudomonas putida</i> ; <i>Hordeum vulgare</i> ; <i>Pseudomonas stutzeri</i> ; <i>Halobacterium</i> sp. NCR-1; <i>Thermus thermophilus</i> ; <i>Caenorhabditis elegans</i>
3695	246	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
3696	247	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
3697	248	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
3698	249	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
3699	250	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
3700	251	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
3701	252	32	<i>Homo sapiens</i>
3702	253	38	<i>Streptomyces coelicolor</i> ; <i>Caulobacter crescentus</i>
3703	254	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
3704	255	33	<i>Rhodobacter sphaeroides</i>
3705	256	75	<i>Mycobacterium tuberculosis</i>
3852	257	44	<i>Streptomyces coelicolor</i> ; <i>Homo sapiens</i> ; <i>Novosphingobium aromaticivorans</i> ; <i>Pan troglodytes</i> ; <i>Mus musculus</i> ; <i>Apterionotus albifrons</i> ; <i>Ralstonia solanacearum</i> ; <i>Sus scrofa</i> ; <i>Gallus gallus</i> ; <i>Oryza sativa</i>
3876	258	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
3877	259	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
3878	260	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
3880	261	32	<i>Mesorhizobium loti</i> ; <i>Rhodopseudomonas palustris</i> ; <i>Ralstonia solanacearum</i>
3881	262	33	<i>Mesorhizobium loti</i> ; <i>Rhodobacter sphaeroides</i>
3882	263	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
3883	264	39	<i>Bacillus halodurans</i>
3884	265	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
4008	266	42	<i>Streptomyces coelicolor</i> ; <i>Mycobacterium tuberculosis</i> ; <i>Mycobacterium leprae</i> ; <i>Deinococcus radiodurans</i> ; <i>Agrobacterium tumefaciens</i> ; <i>Caulobacter crescentus</i>
4412	267	32	<i>Mycobacterium tuberculosis</i> ; <i>Homo sapiens</i> ; <i>Desulfotobacterium hafniense</i>
4769	268	44	<i>Mycobacterium tuberculosis</i> ; <i>Novosphingobium aromaticivorans</i> ; <i>Homo sapiens</i> ; <i>Cricetus griseus</i> ; <i>Suid herpesvirus</i> ; <i>Oryza sativa</i> ; <i>Streptomyces bambergiensis</i> ; <i>Mus musculus</i> ; <i>Caenorhabditis elegans</i>
4769	269	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
4824	270	44	<i>Mycobacterium tuberculosis</i> ; <i>Gallus gallus</i> ; <i>Oryza sativa</i> ; <i>Caulobacter crescentus</i>
4976	271	54	<i>Mycobacterium tuberculosis</i> ; <i>Oryza sativa</i> ; <i>Mycobacterium bovis</i> ; <i>Homo sapiens</i> ; <i>Novosphingobium aromaticivorans</i> ; <i>Mus musculus</i> ; <i>Streptomyces coelicolor</i> ; <i>Deinococcus radiodurans</i> ; <i>Chlamydomonas reinhardtii</i>
5008	272	32	<i>Escherichia coli</i>
5010	273	44	<i>Rhodococcus</i> sp.; <i>Mesorhizobium loti</i>
5012	274	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>

5103	275	51	<i>Ralstonia solanacearum</i> ; <i>Pseudomonas aeruginosa</i> ; <i>Homo sapiens</i> ; <i>Escherichia coli</i> ; <i>Mesorhizobium loti</i> ; <i>Deinococcus radiodurans</i> ; <i>Rhodopseudomonas palustris</i> ; <i>Oryza sativa</i> ; <i>Mycobacterium tuberculosis</i>
5119	276	53	<i>Mycobacterium tuberculosis</i> ; <i>Mycobacterium leprae</i> ; <i>Oryza sativa</i> ; <i>Homo sapiens</i> ; <i>Drosophila melanogaster</i> ; <i>Rhodobacter capsulatus</i> ; <i>Alpha proteobacterium</i> ; <i>Arabidopsis mosaic virus</i>
5186	277	54	<i>Streptomyces coelicolor</i> ; <i>Streptomyces galbus</i>
5188	278	54	<i>Mycobacterium tuberculosis</i> ; <i>Streptomyces coelicolor</i> ; <i>Homo sapiens</i> ; <i>Rhodopseudomonas palustris</i> ; <i>Desulfotobacterium hafniense</i> ; <i>Mus musculus</i>
5306	279	54	<i>Mycobacterium tuberculosis</i>
5316	280	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5317	281	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5326	282	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5328	283	36	<i>Pseudomonas putida</i> ; <i>Magnetospirillum magnetotacticum</i> ; <i>Mycobacterium tuberculosis</i> ; <i>Oryza sativa</i>
5340	284	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5341	285	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5342	286	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5343	287	32	<i>Homo sapiens</i>
5344	288	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5345	289	38	<i>Mesorhizobium loti</i> ; <i>Mycobacterium tuberculosis</i>
5346	290	50	<i>Mycobacterium tuberculosis</i> ; <i>Xanthomonas axonopodis</i> ; <i>Mycobacterium leprae</i> ; <i>Xanthomonas campestris</i>
5348	291	45	<i>Homo sapiens</i>
5349	292	38	<i>Homo sapiens</i> ; <i>Caulobacter crescentus</i>
5350	293	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5351	294	53	<i>Mycobacterium marinum</i> ; <i>Mycobacterium ulcerans</i> ; <i>Leishmania infantum</i> ; <i>Desulfotobacterium hafniense</i> ; <i>Rhizobium meliloti</i> ; <i>Oryza sativa</i>
5352	295	50	<i>Homo sapiens</i> ; <i>Bovine herpesvirus</i> ; <i>Oryza sativa</i> ; <i>Mus musculus</i> ; <i>Burkholderia pseudomallei</i> ; <i>Zea mays</i>
5353	296	39	<i>Anopheles gambiae</i> ; <i>Ralstonia solanacearum</i> ; <i>Drosophila melanogaster</i> ; <i>Poncirus trifoliata</i>
5354	297	38	<i>Rhodobacter sphaeroides</i>
5355	298	50	<i>Pseudomonas syringae</i>
5356	299	39	<i>Streptomyces coelicolor</i> ; <i>Magnetospirillum magnetotacticum</i>
5357	300	38	<i>Homo sapiens</i>
5358	301	32	<i>Desulfotobacterium hafniense</i> ; <i>Rhizobium meliloti</i>
5360	302	44	<i>Drosophila melanogaster</i> ; <i>Ralstonia solanacearum</i>
5361	303	62	<i>Bifidobacterium longum</i> ; <i>Azotobacter vinelandii</i> ; <i>Rhodospirillum rubrum</i> ; <i>Ralstonia solanacearum</i> ; <i>Sinorhizobium meliloti</i> ; <i>Streptomyces lincolnensis</i> ; <i>Oryza sativa</i> ; <i>Xanthomonas axonopodis</i> ; <i>Caulobacter crescentus</i> ; <i>Pseudomonas putida</i> ; <i>Mycobacterium phage DS6A</i> ; <i>Pseudomonas fluorescens</i> ; <i>Burkholderia fungorum</i> ;

			<i>Pseudomonas syringae</i> ; <i>Mycobacterium tuberculosis</i> ; <i>Streptomyces coelicolor</i> ; <i>Pseudomonas aeruginosa</i>
5362	304	50	<i>Ralstonia solanacearum</i>
5363	305	38	<i>Azotobacter vinelandii</i> ; <i>Pseudomonas putida</i>
5364	306	32	<i>Corynebacterium efficiens</i>
5365	307	38	<i>Pseudomonas aeruginosa</i> ; <i>Synechococcus</i> sp.
5366	308	33	<i>Corynebacterium glutamicum</i>
5367	309	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5368	310	32	<i>Nitrosomonas europaea</i>
5369	311	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5370	312	32	<i>Pan troglodytes</i> ; <i>Homo sapiens</i>
5371	313	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5372	314	38	<i>Gluconacetobacter xylinus</i>
5390	315	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5391	316	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5417	317	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5418	318	32	<i>Homo sapiens</i>
5419	319	38	<i>Rhodopseudomonas palustris</i> ; <i>Homo sapiens</i> ; <i>Streptomyces noursei</i> ; <i>Streptomyces coelicolor</i> ; <i>Oryza sativa</i>
5420	320	32	<i>Streptomyces coelicolor</i> ; <i>Streptomyces lividans</i>
5421	321	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5422	322	32	<i>Rhodopseudomonas palustris</i>
5423	323	35	<i>Synechococcus</i> sp.
5424	324	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5425	325	30	<i>Mus musculus</i>
5426	326	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5427	327	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5428	328	35	<i>Homo sapiens</i> ; <i>Comamonas</i> sp.
5429	329	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5430	330	50	<i>Corynebacterium glutamicum</i> ; <i>Burkholderia fungorum</i>
5431	331	30	<i>Mus musculus</i>
5432	332	50	<i>Streptomyces maritimus</i> ; <i>Streptomyces clavuligerus</i> ; <i>Streptomyces lavendulae</i> ; <i>Streptomyces roseofulvus</i>
5433	333	30	<i>Homo sapiens</i>
5434	334	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5435	335	35	<i>Streptomyces clavuligerus</i>
5436	336	45	<i>Ralstonia eutropha</i>
5437	337	40	<i>Rhodobacter sphaeroides</i> ; <i>Thermobifida fusca</i>
5438	338	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5439	339	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5440	340	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5441	341	45	<i>Oryza sativa</i> ; <i>Zea mays</i>
5442	342	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5443	343	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5444	344	36	<i>Haloferax volcanii</i> ; <i>Burkholderia fungorum</i>
5445	345	40	<i>Streptomyces coelicolor</i> ; <i>Ralstonia solanacearum</i>
5446	346	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5447	347	45	<i>Ralstonia solanacearum</i>

5448	348	45	<i>Felis catus</i>
5449	349	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5450	350	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5451	351	35	<i>Burkholderia fungorum</i>
5452	352	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5453	353	92	<i>Desulfitobacterium hafniense</i> ; <i>Streptomyces coelicolor</i> ; <i>Pseudomonas syringae</i> pv. <i>syringae</i> ; <i>Streptomyces verticillus</i> ; <i>Streptomyces avermitilis</i> ; <i>Lysobacter</i> sp. (ATCC 53042); <i>Mycobacterium smegmatis</i> ; <i>Ralstonia solanacearum</i> ; <i>Streptomyces chrysomallus</i> ; <i>Stigmatella aurantiaca</i> ; <i>Streptomyces lavendulae</i> ; <i>Streptomyces toyocaensis</i> ; <i>Mesorhizobium loti</i> ; <i>Saccharothrix mutabilis</i> subsp. <i>capreolus nonribosoma</i> ; <i>Pseudomonas aeruginosa</i> ; <i>Synechococcus</i> sp.
5454	354	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5455	355	33	<i>Halo ferax mediterranei</i>
5456	356	65	<i>Ralstonia solanacearum</i> ; <i>Streptomyces verticillus</i> ; <i>Streptomyces coelicolor</i> ; <i>Desulfitobacterium hafniense</i> ; <i>Streptomyces noursei</i>
5457	357	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5458	358	57	<i>Streptomyces verticillus</i> ; <i>Streptomyces chrysomallus</i> ; <i>Streptomyces avermitilis</i> ; <i>Pseudomonas syringae</i> pv. <i>syringae</i> ; <i>Streptomyces coelicolor</i> ; <i>Streptomyces lavendulae</i> ; <i>Azotobacter vinelandii</i> ; <i>Pseudomonas fluorescens</i> ; <i>Magnetospirillum magnetotacticum</i> ; <i>Thermobifida fusca</i> ; <i>Desulfitobacterium hafniense</i> ; <i>Ralstonia solanacearum</i>
5459	359	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5460	360	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5461	361	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5462	362	32	<i>Leishmania major</i>
5463	363	37	<i>Burkholderia fungorum</i> ; <i>Nitrosomonas europaea</i> ; <i>Pseudomonas</i> sp.
5464	364	41	<i>Pseudomonas putida</i> ; <i>Sinorhizobium meliloti</i>
5465	365	32	<i>Rhodobacter capsulatus</i> ; <i>Rat cytomegalovirus</i>
5466	366	37	<i>Pseudomonas fluorescens</i> ; <i>Rhodopseudomonas palustris</i>
5467	367	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5468	368	33	<i>Rhodobacter sphaeroides</i>
5469	369	37	<i>Rhodobacter sphaeroides</i> ; <i>Oryza sativa</i> ; <i>Homo sapiens</i>
5470	370	40	<i>Bifidobacterium longum</i> ; <i>Caulobacter maris</i> ; <i>Xanthomonas axonopodis</i> pv. <i>citri</i>
5471	371	33	<i>Burkholderia fungorum</i> ; <i>Streptomyces avermitilis</i>
5472	372	50	<i>Streptomyces coelicolor</i>
5473	373	39	<i>Rhodobacter sphaeroides</i> ; <i>Mycobacterium tuberculosis</i> ; <i>Pseudomonas aeruginosa</i>
5474	374	45	<i>Pseudomonas aeruginosa</i>
5475	375	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5476	376	45	<i>Xanthomonas campestris</i> pv. <i>Campestris</i> (ATCC 3391)
5477	377	44	<i>Mesorhizobium loti</i> ; <i>Azotobacter vinelandii</i> ; <i>Salmonella</i>

			<i>enterica</i> serovar <i>typhi</i>
5478	378	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5479	379	37	<i>Zea mays</i>
5480	380	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5481	381	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5482	382	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5483	383	33	<i>Leishmania major</i>
5484	384	32	<i>Homo sapiens</i> ; <i>Ralstonia solanacearum</i>
5485	385	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5486	386	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5487	387	32	<i>Caulobacter crescentus</i> pv. <i>citri</i>
5488	388	32	<i>Xanthomonas axonopodis</i>
5489	389	35	<i>Sinorhizobium meliloti</i>
5490	390	50	<i>Pseudomonas syringae</i> pv. <i>syringae</i> ; <i>Xanthomonas axonopodis</i> pv. <i>citri</i> ; <i>Shigella flexneri</i>
5491	391	32	<i>Leishmania major</i>
5492	392	74	<i>Pseudomonas fluorescens</i> ; <i>Pseudomonas aeruginosa</i> ; <i>Sorangium cellulosum</i> ; <i>Drosophila melanogaster</i>
5493	393	83	<i>Yersinia enterocolitica</i> ; <i>Yersinia pestis</i> ; <i>Azotobacter vinelandii</i> ; <i>Escherichia coli</i> ; <i>Ralstonia solanacearum</i> ; <i>Streptomyces avermitilis</i> ; <i>Pseudomonas fluorescens</i> ; <i>Mycobacterium smegmatis</i> ; <i>Streptomyces verticillus</i> ; <i>Streptomyces atroolivaceus</i>
5494	394	50	<i>Mesorhizobium loti</i> ; <i>Oryza sativa</i> ; <i>Novosphingobium aromaticivorans</i> ; <i>Halobacterium</i> sp. NRC-1; <i>Torrubiella arachnophilus</i>
5495	395	33	<i>Agrobacterium tumefaciens</i>
5496	396	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5497	397	32	<i>Streptomyces coelicolor</i>
5498	398	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5499	399	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5501	400	44	<i>Oryza sativa</i>
5502	401	35	<i>Xanthomonas campestris</i> pv. <i>campestris</i> (ATCC 3391)
5503	402	33	<i>Corynebacterium efficiens</i>
5504	403	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5505	404	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5506	405	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5507	406	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5508	407	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5509	408	37	<i>Mus musculus</i> ; <i>Homo sapiens</i>
5510	409	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5511	410	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5512	411	37	<i>Pseudomonas fluorescens</i>
5513	412	44	<i>Rhodospirillum rubrum</i> ; <i>Xanthomonas axonopodis</i> pv. <i>citri</i>
5514	413	37	<i>Plasmodium vivax</i>
5515	414	32	<i>Pseudomonas putida</i>
5516	415	32	<i>Ralstonia solanacearum</i>
5517	416	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>

5518	417	37	<i>Streptomyces coelicolor</i>
5519	418	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5520	419	49	<i>Anopheles stephensi</i> ; <i>Drosophila melanogaster</i>
5524	420	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5525	421	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5526	422	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5527	423	37	<i>Mus musculus</i>
5528	424	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5529	425	32	<i>Ralstonia solanacearum</i>
5530	426	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5531	427	37	<i>Azotobacter vinelandii</i>
5532	428	32	<i>Schizosaccharomyces pombe</i>
5533	429	33	<i>Streptomyces fradiae</i>
5535	430	105	<i>Mycobacterium avium</i> ; <i>Desulfitobacterium hafniense</i>
5538	431	119	<i>Streptomyces fradiae</i> ; <i>Mycobacterium avium</i> subsp. <i>avium</i> ; <i>Homo sapiens</i> ; <i>Synechococcus</i> sp.
5539	432	80	<i>Mycobacterium avium</i>
5541	433	71	<i>Mycobacterium avium</i> ; <i>Sinorhizobium meliloti</i>
5542	434	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5543	435	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5544	436	37	<i>Triglochin maritima</i>
5545	437	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5546	438	32	<i>Pseudomonas syringae</i> pv. <i>syringae</i>
5547	439	37	<i>Mycobacterium tuberculosis</i>
5548	440	37	<i>Mycobacterium leprae</i>
5550	441	146	<i>Mycobacterium tuberculosis</i> ; <i>Mycobacterium smegmatis</i> ; <i>Mycobacterium avium</i> (strain 2151)
5551	442	54	<i>Mycobacterium tuberculosis</i>
5553	443	111	<i>Mycobacterium tuberculosis</i> ; <i>Mycobacterium leprae</i> ; <i>Mycobacterium avium</i> (strain 2151)
5555	444	101	<i>Mycobacterium tuberculosis</i>
5556	445	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5558	446	77	<i>Mycobacterium avium</i> (strain 2151); <i>Mycobacterium tuberculosis</i> ; <i>Plasmodium falciparum</i> ; <i>Thermobifida fusca</i> ; <i>Mus musculus</i> ; <i>Xanthomonas campestris</i> pv. <i>Campestris</i> (ATCC 3391); <i>Mycobacterium smegmatis</i> ; <i>Medicago truncatula</i>
5559	447	108	<i>Mycobacterium tuberculosis</i>
5567	448	53	<i>Mycobacterium tuberculosis</i>
5568	449	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5569	450	77	<i>Mycobacterium tuberculosis</i>
5570	451	71	<i>Mycobacterium leprae</i>
5571	452	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5572	453	102	<i>Mycobacterium tuberculosis</i> ; <i>Mycobacterium bovis</i>
5573	454	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5574	455	32	<i>Rattus norvegicus</i>
5575	456	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5576	457	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5577	458	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>

5578	459	32	<i>Bacteroides thetaiotaomicron</i>
5579	460	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5580	461	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5581	462	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5582	463	35	<i>Pseudomonas aeruginosa</i>
5583	464	37	<i>Mycobacterium tuberculosis</i>
5584	465	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5585	466	32	<i>Homo sapiens</i>
5586	467	44	<i>Salmonella enterica</i> serovar <i>typhi</i> ; <i>Salmonella typhimurium</i>
5587	468	30	<i>Caenorhabditis elegans</i>
5588	469	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5589	470	75	<i>Streptomyces lavendulae</i> ; <i>Mycobacterium tuberculosis</i> ; <i>Homo sapiens</i> ; <i>Mus musculus</i>
5590	471	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5591	472	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5592	473	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5593	474	30	<i>Homo sapiens</i>
5594	475	30	<i>Homo sapiens</i>
5595	476	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5596	477	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5597	478	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5598	479	36	<i>Burkholderia fungorum</i>
5599	480	30	<i>Homo sapiens</i>
5600	481	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5601	482	65	<i>Mycobacterium tuberculosis</i>
5609	483	100	<i>Mycobacterium tuberculosis</i>
5610	484	55	<i>Mycobacterium tuberculosis</i>
5611	485	30	<i>Mus musculus</i>
5612	486	30	<i>Danio rerio</i>
5613	487	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5614	488	36	<i>Salmonella enteritidis</i>
5615	489	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5616	490	110	<i>Mycobacterium tuberculosis</i> ; <i>Mycobacterium avium</i> ; <i>Mycobacterium leprae</i> ; <i>Nocardia brasiliensis</i> ; <i>Streptomyces antibioticus</i> ; <i>Streptomyces galilaeus</i> ; <i>Streptomyces avermitilis</i> ; <i>Agrobacterium tumefaciens</i> ; <i>Streptomyces narbonneensis</i>
5617	491	75	<i>Mycobacterium tuberculosis</i> ; <i>Mycobacterium leprae</i> ; <i>Xanthomonas axonopodis</i>
5618	492	50	<i>Mycobacterium avium</i>
5619	493	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5620	494	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5621	495	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5622	496	30	<i>Nostoc</i> sp.
5623	497	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5624	498	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5625	499	60	<i>Mycobacterium tuberculosis</i> ; <i>Xanthomonas axonopodis</i>
5626	500	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>

5627	501	75	<i>Mycobacterium tuberculosis</i>
5628	502	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5629	503	30	<i>Burkholderia fungorum</i>
5630	504	80	<i>Mycobacterium tuberculosis</i>
5631	505	110	<i>Mycobacterium tuberculosis</i>
5633	506	65	<i>Mycobacterium tuberculosis</i>
5634	507	80	<i>Mycobacterium tuberculosis</i> ; <i>Mycobacterium bovis</i>
5635	508	110	<i>Mycobacterium tuberculosis</i> ; <i>Mycobacterium leprae</i> ; <i>Mycobacterium bovis</i>
5639	509	55	<i>Mycobacterium tuberculosis</i> ; <i>Homo sapiens</i> ; <i>Pseudomonas fluorescens</i> ; <i>Oryza sativa</i>
5640	510	60	<i>Rhodospirillum rubrum</i> ; <i>Mycobacterium bovis</i> ; <i>Mycobacterium tuberculosis</i>
5641	511	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5642	512	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5643	513	45	<i>Mycobacterium bovis</i> ; <i>Mycobacterium tuberculosis</i> ; <i>Mus musculus</i>
5644	514	45	<i>Sorangium cellulosum</i>
5645	515	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5646	516	65	<i>Mycobacterium tuberculosis</i> ; <i>Myxococcus xanthus</i>
5647	517	37	<i>Azotobacter vinelandii</i> ; <i>Mycobacterium tuberculosis</i>
5648	518	75	<i>Mycobacterium leprae</i> ; <i>Mycobacterium bovis</i> ; <i>Mycobacterium tuberculosis</i> ; <i>Azotobacter vinelandii</i> ; <i>Streptomyces</i> sp.; <i>Mus musculus</i>
5649	519	120	<i>Mycobacterium tuberculosis</i> ; <i>Mycobacterium bovis</i> ; <i>Stigmatella aurantiaca</i> ; <i>Micromonospora megalomicea</i> ; <i>Streptomyces hygroscopicus</i>
5650	520	110	<i>Mycobacterium tuberculosis</i> ; <i>Mycobacterium bovis</i> ; <i>Bovine herpesvirus</i> ; <i>Pseudomonas aeruginosa</i>
5652	521	70	<i>Mycobacterium tuberculosis</i> ; <i>Mycobacterium leprae</i> ; <i>Streptomyces avermitilis</i>
5653	522	50	<i>Mycobacterium tuberculosis</i>
5654	523	95	<i>Saccharopolyspora erythraea</i> ; <i>Mycobacterium leprae</i> ; <i>Mycobacterium tuberculosis</i> ; <i>Homo sapiens</i> ; <i>Caulobacter crescentus</i> ; <i>Mus musculus</i> ; <i>Streptomyces nodosus</i>
5657	524	55	<i>Mesorhizobium loti</i> ; <i>Mycobacterium tuberculosis</i>
5658	525	55	<i>Mycobacterium bovis</i> ; <i>Mycobacterium tuberculosis</i> ; <i>Streptomyces</i> sp.
5660	526	75	<i>Mycobacterium tuberculosis</i>
5661	527	30	<i>Sinorhizobium meliloti</i>
5662	528	75	<i>Mycobacterium tuberculosis</i> ; <i>Amycolatopsis orientalis</i>
5663	529	75	<i>Mycobacterium tuberculosis</i>
5665	530	30	<i>Gallus gallus</i>
5667	531	45	<i>Desulfotobacterium hafniense</i> ; <i>Ralstonia solanacearum</i> ; <i>Streptomyces coelicolor</i> ; <i>Oryza sativa</i> ; <i>Zea mays</i>
5669	532	60	<i>Mycobacterium tuberculosis</i> ; <i>Desulfotobacterium hafniense</i> ; <i>Oryza sativa</i>
5679	533	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5681	534	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>

5682	535	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5686	536	45	<i>Mycobacterium avium</i>
5688	537	30	<i>Myxococcus xanthus</i> ; <i>Ralstonia metallidurans</i>
5690	538	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5691	539	48	<i>Corynebacterium efficiens</i> ; <i>Novosphingobium aromaticivorans</i> ; <i>Escherichia coli</i>
5692	540	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5693	541	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5694	542	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5695	543	33	<i>Amycolatopsis orientalis</i>
5697	544	55	<i>Magnetospirillum magnetotacticum</i> ; <i>Ralstonia solanacearum</i> ; <i>Caulobacter crescentus</i>
5700	545	32	<i>Enterococcus saccharolyticus</i>
5701	546	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5702	547	32	<i>Oryza sativa</i>
5703	548	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5704	549	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5705	550	32	<i>Magnetospirillum magnetotacticum</i>
5707	551	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5708	552	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5709	553	62	<i>Mycobacterium tuberculosis</i> ; <i>Bifidobacterium longum</i> ; <i>Neisseria meningitidis</i> ; <i>Bifidobacterium longum</i> ; <i>Streptomyces avermitilis</i> ; <i>Mesorhizobium loti</i> ; <i>Chloroflexus aurantiacus</i> ; <i>Xylella fastidiosa</i> ; <i>Pseudomonas syringae</i> pv. <i>syringae</i> ; <i>Corynebacterium efficiens</i> ; <i>Agrobacterium tumefaciens</i> ; <i>Nitrosomonas europaea</i> ; <i>Rhodobacter capsulatus</i> ; <i>Ralstonia solanacearum</i> ; <i>Sinorhizobium meliloti</i> ; <i>Halobacterium</i> sp.
5710	554	70	<i>Rhodospirillum rubrum</i> ; <i>Pseudomonas resinovorans</i>
5711	555	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5712	556	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5713	557	39	<i>Pseudomonas aeruginosa</i> ; <i>Ralstonia metallidurans</i> ; <i>Xanthomonas campestris</i> ; <i>Xanthomonas axonopodis</i>
5714	558	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5715	559	32	<i>Pseudomonas aeruginosa</i>
5716	560	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5746	561	138	<i>Mycobacterium leprae</i> ; <i>Mycobacterium tuberculosis</i> ; <i>Homo sapiens</i> ; <i>Streptomyces coelicolor</i> ; <i>Oryza sativa</i>
5767	562	42	<i>Oryza sativa</i> ; <i>Triticum aestivum</i> ; <i>Ralstonia solanacearum</i> ; <i>Agrobacterium tumefaciens</i> ; <i>Drosophila melanogaster</i> ; <i>Hordeum vulgare</i>
5859	563	44	<i>Homo sapiens</i> ; <i>Festuca arundinacea</i> ; <i>Oryza sativa</i> ; <i>Rhodospirillum rubrum</i> ; <i>Magnetospirillum magnetotacticum</i> ; <i>Lolium perenne</i> ; <i>Mesorhizobium loti</i> ; <i>Xanthomonas axonopodis</i> ; <i>Caulobacter crescentus</i> ; <i>Chlamydomonas reinhardtii</i>
5860	564	48	<i>Homo sapiens</i> ; <i>Rhodospirillum rubrum</i> ; <i>Ralstonia solanacearum</i> ; <i>Mus musculus</i> ; <i>Mycobacterium tuberculosis</i> ; <i>Oryza sativa</i> ; <i>Streptomyces coelicolor</i>

5922	565	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5923	566	86	<i>Mycobacterium leprae</i> ; <i>Pseudomonas aeruginosa</i>
5925	567	39	<i>Mycobacterium leprae</i>
5926	568	39	<i>Mycobacterium leprae</i> ; <i>Streptomyces nodosus</i> ; <i>Rhodospirillum rubrum</i> ; <i>Magnetospirillum magnetotacticum</i> ; <i>Novosphingobium aromaticivorans</i>
5929	569	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5933	570	32	<i>Homo sapiens</i>
5934	571	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5935	572	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5936	573	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5937	574	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5938	575	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5939	576	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5940	577	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5941	578	32	<i>Pseudomonas putida</i>
5942	579	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5943	580	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5944	581	32	<i>Saccharomyces cerevisiae</i>
5945	582	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5946	583	33	<i>Mus musculus</i>
5947	584	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5948	585	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5949	586	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5950	587	32	<i>Brucella melitensis</i> ; <i>Brucella suis</i>
5951	588	32	<i>Desulfitobacterium hafniense</i>
5952	589	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5953	590	51	<i>Rhodopseudomonas palustris</i>
5954	591	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
5955	592	74	<i>Mycobacterium leprae</i> ; <i>Mycobacterium tuberculosis</i> ; <i>Thermobifida fusca</i> ; <i>Pseudomonas</i> sp.; <i>Streptomyces coelicolor</i> ; <i>Mycobacterium bovis</i> ; <i>Pseudomonas fluorescens</i> ; <i>Bifidobacterium longum</i> ; <i>Corynebacterium efficiens</i> ; <i>Rhodospirillum rubrum</i> ; <i>Corynebacterium glutamicum</i> ; <i>Agrobacterium tumefaciens</i> ; <i>Shewanella oneidensis</i> ; <i>Rhodobacter capsulatus</i> ; <i>Methanosarcina barkeri</i> ; <i>Methanosarcina acetivorans</i>
5969	593	44	<i>Pseudomonas denitrificans</i> ; <i>Mus musculus</i> ; <i>Mycobacterium tuberculosis</i> ; <i>Tupaia herpesvirus</i>
5973	594	50	<i>Streptomyces coelicolor</i> ; <i>Merxmuellera davyi</i> ; <i>Gallus gallus</i> ; <i>Magnetospirillum magnetotacticum</i> ; <i>Rhodobacter capsulatus</i> ; <i>Deinococcus radiodurans</i> ; <i>Mus musculus</i>
5981	595	41	<i>Ralstonia solanacearum</i> ; <i>Homo sapiens</i> ; <i>Sus scrofa</i> ; <i>Oryza sativa</i> ; <i>Mus musculus</i>
5995	596	48	<i>Homo sapiens</i> ; <i>Frankia</i> sp.; <i>Phleum pratense</i> ; <i>Oryza sativa</i> ; <i>Streptomyces plicatus</i> ; <i>Mus musculus</i> ; <i>Canis familiaris</i> ; <i>Streptomyces violaceoruber</i> ; <i>Streptomyces coelicolor</i>
6028	597	81	<i>Mycobacterium tuberculosis</i> ; <i>Xanthomonas axonopodis</i> ;

			<i>Leishmania major</i>
6053	598	102	<i>Trypanosoma cruzi</i> ; <i>Crematogaster smithi</i> ; <i>Salmonella typhimurium</i> ; <i>Leishmania major</i> ; <i>Xanthomonas campestris</i> ; <i>Mus musculus</i> ; <i>Nitrosomonas europaea</i> ; <i>Drosophila melanogaster</i> ; <i>Homo sapiens</i>
6185	599	37	<i>Streptomyces coelicolor</i> ; <i>Streptomyces lividans</i> ; <i>Xanthomonas campestris</i>
6200	600	35	<i>Acetobacter xylinus</i>
6201	601	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
6202	602	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
6203	603	33	<i>Chlamydomonas reinhardtii</i>
6204	604	86	<i>Mycobacterium tuberculosis</i> ; <i>Burkholderia fungorum</i> ; <i>Corynebacterium efficiens</i>
6206	605	38	<i>Mycobacterium tuberculosis</i>
6210	606	84	<i>Mycobacterium tuberculosis</i> ; <i>Mycobacterium bovis</i> ; <i>Mycobacterium leprae</i> ; <i>Polycentropus flavomaculatus</i> ; <i>Caulobacter crescentus</i> ; <i>Homo sapiens</i> ; <i>Burkholderia fungorum</i> ; <i>Oryza sativa</i> ; <i>Cowdria ruminantium</i> ; <i>Pseudomonas aeruginosa</i>
6230	607	51	<i>Rhodopseudomonas palustris</i> ; <i>Homo sapiens</i> ; <i>Oryza sativa</i> ; <i>Leishmania major</i> ; <i>Mycobacterium tuberculosis</i> ; <i>Mesorhizobium loti</i> ; <i>Ralstonia solanacearum</i> ; <i>Streptomyces pristinaespiralis</i> ; <i>Frankia</i> sp.
6396	608	33	<i>Desulfitobacterium hafniense</i> ; <i>Mycobacterium tuberculosis</i>
6400	609	50	<i>Mus musculus</i> ; <i>Burkholderia fungorum</i> ; <i>Drosophila melanogaster</i>
6633	610	45	<i>Ralstonia solanacearum</i> ; <i>Homo sapiens</i> ; <i>Caulobacter crescentus</i> ; <i>Gluconacetobacter xylinus</i> ; <i>Rhodobacter sphaeroides</i> ; <i>Rhodospirillum rubrum</i> ; <i>Mycobacterium leprae</i> ; <i>Oryza sativa</i> ; <i>Pseudomonas aeruginosa</i> ; <i>Pseudomonas putida</i>
6695	611	74	<i>Homo sapiens</i> ; <i>Rattus norvegicus</i> ; <i>Mus musculus</i>
6773	612	56	<i>Homo sapiens</i> ; <i>Mus musculus</i> ; <i>Streptomyces coelicolor</i> ; <i>Hormoconis resinae</i> ; <i>Drosophila melanogaster</i> ; <i>Oryza sativa</i> ; <i>Gallus gallus</i>
6892	613	56	<i>Homo sapiens</i> ; <i>Papio anubis</i>
6893	614	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
6894	615	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
6895	616	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
6896	617	32	<i>Mesorhizobium loti</i> ; <i>Mus musculus</i> ; <i>Rhodopseudomonas palustris</i>
6897	618	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
6899	619	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
6900	620	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
6901	621	32	<i>Burkholderia fungorum</i>
6902	622	32	<i>Caenorhabditis elegans</i>
6903	623	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
6904	624	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>

6905	625	33	<i>Homo sapiens</i>
6910	626	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
6911	627	32	<i>Magnetospirillum magnetotacticum</i>
6912	628	33	<i>Oryza sativa</i> ; <i>Rhodobacter sphaeroides</i> ; <i>Halobacterium</i> sp. NRC-1
6987	629	44	<i>Klebsiella pneumoniae</i> ; <i>Burkholderia fungorum</i> ; <i>Streptomyces coelicolor</i> ; <i>Oryza sativa</i> ; <i>Ralstonia metallidurans</i> ; <i>Halobacterium</i> sp. NRC-1
7088	630	90	<i>Mycobacterium tuberculosis</i> ; <i>Ralstonia solanacearum</i> ; <i>Rhodobacter sphaeroides</i> ; <i>Ralstonia metallidurans</i> ; <i>Novosphingobium aromaticivorans</i> ; <i>Desulfitobacterium hafniense</i> ; <i>Bovine herpesvirus</i> type 1
7089	631	39	<i>Mesorhizobium loti</i> ; <i>Streptomyces coelicolor</i> ; <i>Burkholderia fungorum</i> ; <i>Desulfitobacterium hafniense</i> ; <i>Oryza sativa</i> ; <i>Methylovorus</i> sp.
7113	632	75	<i>Pseudopleuronectes americanus</i> ; <i>Mycobacterium tuberculosis</i> ; <i>Mus musculus</i> ; <i>Urochloa panicoides</i> ; <i>Oryza sativa</i> ; <i>Streptomyces coelicolor</i>
7181	633	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
7254	634	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
7363	635	36	<i>Pseudomonas aeruginosa</i>
7364	636	36	<i>Ralstonia solanacearum</i>
7365	637	32	<i>Streptomyces coelicolor</i>
7366	638	35	<i>Zantedeschia aethiopica</i> ; <i>Streptomyces coelicolor</i>
7367	639	32	<i>Paucimonas lemoignei</i>
7562	640	102	<i>Mycobacterium tuberculosis</i> ; <i>Mus musculus</i> ; <i>Homo sapiens</i> ; <i>Desulfitobacterium hafniense</i> ; <i>Ralstonia solanacearum</i> ; <i>Salmonella typhimurium</i>
7592	641	137	<i>Mycobacterium tuberculosis</i> ; <i>Streptomyces atroolivaceus</i> ; <i>Ralstonia solanacearum</i> ; <i>Lysobacter enzymogenes</i> ; <i>Leishmania major</i> ; <i>Cupiennius salei</i> ; <i>Oryza sativa</i> ; <i>Streptomyces coelicolor</i> ; <i>Pseudomonas aeruginosa</i> ; <i>Cercopithecine herpesvirus</i> 15
7731	642	57	<i>Magnetospirillum magnetotacticum</i> ; <i>Oryza sativa</i> ; <i>Mycobacterium tuberculosis</i> ; <i>Desulfitobacterium hafniense</i> ; <i>Rhodopseudomonas palustris</i> ; <i>Pseudomonas aeruginosa</i> ; <i>Homo sapiens</i>
7762	643	99	<i>Mycobacterium tuberculosis</i> ; <i>Streptomyces coelicolor</i> ; <i>Desulfitobacterium hafniense</i> ; <i>Oryza sativa</i> ; <i>Streptomyces avermitilis</i>
7974	644	38	<i>Desulfitobacterium hafniense</i> ; <i>Oryza sativa</i> ; <i>Mycobacterium tuberculosis</i> ; <i>Salmonella typhimurium</i> ; <i>Pseudomonas fluorescens</i> ; <i>Azotobacter vinelandii</i> ; <i>Spermatozopsis similis</i>
8146	645	39	<i>Oryza sativa</i> ; <i>Homo sapiens</i>
8196	646	119	<i>Mycobacterium tuberculosis</i> ; <i>Mycobacterium leprae</i> ; <i>Magnetospirillum magnetotacticum</i> ; <i>Oryza sativa</i>
8208	647	57	<i>Xanthomonas campestris</i> ; <i>Mycobacterium tuberculosis</i> ; <i>Deinococcus radiodurans</i>

8240	648	44	<i>Chlamydomonas reinhardtii</i>
8291	649	93	<i>Mycobacterium tuberculosis</i>
8292	650	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
8293	651	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
8294	652	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
8295	653	32	<i>Mycobacterium tuberculosis</i>
8296	654	45	<i>Xanthomonas campestris</i> ; <i>Streptomyces nigrifaciens</i> ; <i>Streptomyces phaeochromogenes</i> ; <i>Streptomyces noursei</i>
8297	655	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
8298	656	50	<i>Desulfitobacterium hafniense</i>
8299	657	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
8300	658	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
8301	659	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
8302	660	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
8303	661	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
8304	662	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
8305	663	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
8306	664	36	<i>Arabidopsis thaliana</i>
8307	665	33	<i>Xanthomonas axonopodis</i>
8308	666	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
8309	667	37	<i>Pseudomonas putida</i> ; <i>Mycobacterium smegmatis</i>
8461	668	37	<i>Oryza sativa</i> ; <i>Homo sapiens</i>
8619	669	53	<i>Oryza sativa</i> ; <i>Homo sapiens</i> ; <i>Rhodospirillum rubrum</i> ; <i>Rhizobium meliloti</i> (<i>Sinorhizobium meliloti</i>)
8628	670	32	<i>Homo sapiens</i>
8632	671	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
8633	672	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
8634	673	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
8635	674	32	<i>Homo sapiens</i> ; <i>Pseudomonas fluorescens</i>
8636	675	45	<i>Drosophila melanogaster</i>
8667	676	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
8668	677	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
8669	678	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
8670	679	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
8671	680	33	<i>Ralstonia metallidurans</i> ; <i>Pseudomonas syringae</i> pv. <i>syringae</i> ; <i>Homo sapiens</i>
8672	681	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
8673	682	32	<i>Rhodospirillum rubrum</i> ; <i>Caenorhabditis elegans</i>
8744	683	44	<i>Novosphingobium aromaticivorans</i> ; <i>Oryza sativa</i> ; <i>Rhodopseudomonas palustris</i> ; <i>Magnetospirillum</i> <i>magnetotacticum</i> ; <i>Corynebacterium glutamicum</i> ; <i>Listeria</i> <i>innocua</i> ; <i>Streptomyces coelicolor</i>
8860	684	144	<i>Mycobacterium tuberculosis</i> ; <i>Streptomyces coelicolor</i> ; <i>Halobacterium</i> sp.NRC-1; <i>Mycobacterium leprae</i> ; <i>Pseudomonas aeruginosa</i>
8927	685	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
8935	686	47	<i>Mycobacterium avium</i> (strain 2151); <i>Mus musculus</i>
8936	687	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
8937	688	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>

8938	689	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
8939	690	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
8940	691	32	<i>Triticum aestivum</i>
9022	692	60	<i>Streptomyces coelicolor</i> ; <i>Ralstonia solanacearum</i> ; <i>Microbulbifer degradans</i> ; <i>Streptomyces seoulensis</i> ; <i>Caulobacter crescentus</i> ; <i>Pseudomonas aeruginosa</i> ; <i>Burkholderia fungorum</i> ; <i>Corynebacterium efficiens</i>
9126	693	102	<i>Mycobacterium smegmatis</i> ; <i>Mycobacterium leprae</i> ; <i>Saccharopolyspora erythraea</i>
9156	694	57	<i>Mycobacterium avium</i> (ATCC 35712); <i>Mycobacterium intracellulare</i>
9247	695	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
9248	696	39	<i>Corynebacterium efficiens</i> ; <i>Deinococcus radiodurans</i>
9249	697	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
9250	698	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
9272	699	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
9273	700	44	<i>Streptomyces avermitilis</i> ; <i>Magnetospirillum magnetotacticum</i> ; <i>Caulobacter crescentus</i> ; <i>Corynebacterium striatum</i>
9274	701	32	<i>Homo sapiens</i> ; <i>Halobacterium</i> sp. NRC-1
9275	702	39	<i>Caenorhabditis elegans</i> ; <i>Pseudomonas fluorescens</i> ; <i>Streptomyces coelicolor</i> ; <i>Deinococcus radiodurans</i>
9276	703	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
9277	704	37	<i>Desulfobacterium hafniense</i> ; <i>Ralstonia solanacearum</i>
9278	705	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
9279	706	37	<i>Agrobacterium tumefaciens</i> ; <i>Oryza sativa</i>
9280	707	99	<i>Mycobacterium tuberculosis</i>
9283	708	32	<i>Oryza sativa</i>
9284	709	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
9285	710	89	<i>Mycobacterium tuberculosis</i>
9286	711	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
9287	712	63	<i>Mycobacterium tuberculosis</i> ; <i>Novosphingobium aromaticivorans</i>
9288	713	36	<i>Alcaligenes eutrophus</i>
9289	714	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
9290	715	41	<i>Ictalurid herpesvirus 1</i> (channel catfish virus)
9291	716	32	<i>Rhodobacter sphaeroides</i>
9292	717	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
9293	718	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
9294	719	32	<i>Drosophila melanogaster</i>
9295	720	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
9296	721	32	<i>Glycine max</i>
9297	722	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
9298	723	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
9299	724	32	<i>Homo sapiens</i>
9300	725	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
9301	726	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
9302	727	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
9303	728	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>

9304	729	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
9305	730	32	<i>Homo sapiens</i>
9306	731	32	<i>Zea mays</i>
9307	732	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
9308	733	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
9309	734	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
9310	735	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
9311	736	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
9312	737	37	<i>Synechococcus</i> sp.
9313	738	41	<i>Pseudomonas aeruginosa</i>
9314	739	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
9315	740	45	<i>Pseudomonas fluorescens</i> ; <i>Drosophila melanogaster</i> ; <i>Homo sapiens</i>
9316	741	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
9317	742	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
9318	743	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
9326	744	42	<i>Mycobacterium avium</i> ; <i>Homo sapiens</i>
9327	745	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
9328	746	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
9329	747	32	<i>Drosophila melanogaster</i>
9330	748	32	<i>Homo sapiens</i>
9331	749	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
9332	750	32	<i>Halobacterium salinarum</i>
9333	751	44	<i>Magnetospirillum magnetotacticum</i> ; <i>Ralstonia solanacearum</i> ; <i>Sinorhizobium meliloti</i>
9335	752	37	<i>Xanthomonas albilineans</i>
9336	753	37	<i>Micromonospora griseorubida</i>
9337	754	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
9338	755	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
9339	756	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
9340	757	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
9341	758	37	<i>Pseudomonas paucimobilis</i>
9342	759	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
9343	760	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
9344	761	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
9345	762	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
9346	763	47	<i>Streptomyces coelicolor</i>
9347	764	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
9348	765	32	<i>Magnetospirillum magnetotacticum</i>
9349	766	33	<i>Burkholderia fungorum</i>
9350	767	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
9351	768	33	<i>Homo sapiens</i> ; <i>Mycobacterium bovis</i> ; <i>Mycobacterium tuberculosis</i>
9360	769	42	<i>Oryza sativa</i> ; <i>Triticum aestivum</i> ; <i>Homo sapiens</i> ; <i>Mus musculus</i> ; <i>Magnetospirillum magnetotacticum</i> ; <i>Hordeum vulgare</i> ; <i>Streptomyces fradiae</i>
9604	770	71	<i>Sus scrofa</i> ; <i>Desulfitobacterium hafniense</i> ; <i>Mycobacterium tuberculosis</i> ; <i>Mus musculus</i> ; <i>Homo sapiens</i> ; <i>Oryza sativa</i> ; <i>Sinorhizobium meliloti</i>

9713	771	44	<i>Deinococcus radiodurans</i> ; <i>Burkholderia fungorum</i> ; <i>Desulfovibrio desulfuricans</i> ; <i>Mycobacterium tuberculosis</i>
9737	772	75	<i>Mycobacterium tuberculosis</i> ; <i>Mycobacterium leprae</i>
9760	773	141	<i>Mycobacterium tuberculosis</i> ; <i>Mus musculus</i> ; <i>Rhodopseudomonas palustris</i> ; <i>Streptomyces coelicolor</i> ; <i>Mycobacterium leprae</i> ; <i>Rattus norvegicus</i> ; <i>Alcaligenes faecalis</i> ; <i>Homo sapiens</i> ; <i>Leishmania major</i> ; <i>Burkholderia fungorum</i> ; <i>Azotobacter vinelandii</i> ; <i>Oryza sativa</i> ; <i>Xanthomonas axonopodis</i>
9769	774	63	<i>Streptomyces castaneoglobisporus</i> ; <i>Mus musculus</i> ; <i>Homo sapiens</i> ; <i>Ralstonia metallidurans</i> ; <i>Oryza sativa</i> ; <i>Chlamydomonas reinhardtii</i> ; <i>Mycobacterium tuberculosis</i> ; <i>Deinococcus radiodurans</i>
9826	775	69	<i>Acidithiobacillus ferrooxidans</i> ; <i>Rhodobacter sphaeroides</i> ; <i>Mycobacterium leprae</i> ; <i>Rhodopseudomonas palustris</i> ; <i>Oryza sativa</i>
9830	776	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
9928	777	37	<i>Homo sapiens</i> ; <i>Magnetospirillum magnetotacticum</i> ; <i>Oryza sativa</i> ; <i>Caulobacter crescentus</i> ; <i>Pan troglodytes</i>
9960	778	32	<i>Mycobacterium tuberculosis</i>
9961	779	39	<i>Pseudomonas aeruginosa</i>
9962	780	33	<i>Streptomyces noursei</i> ; <i>Burkholderia fungorum</i> ; <i>Oryza sativa</i> ; <i>Azospirillum brasilense</i>
9963	781	32	<i>Burkholderia mallei</i>
9964	782	41	<i>Mycobacterium leprae</i> ; <i>Bifidobacterium longum</i>
9965	783	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
9966	784	37	<i>Sphingobacterium multivorum</i> ; <i>Rhodopseudomonas palustris</i> ; <i>Synechococcus</i> sp.
9967	785	35	<i>Pseudomonas aeruginosa</i>
9968	786	37	<i>Rhizobium leguminosarum</i> pv. <i>viciae</i> ; <i>Oryza sativa</i>
9969	787	39	<i>Streptomyces cinnamonensis</i> ; <i>Homo sapiens</i>
10259	788	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
10260	789	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
10261	790	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
10262	791	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
10263	792	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
10264	793	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
10265	794	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
10266	795	33	<i>Pseudomonas putida</i>
10268	796	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
10269	797	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
10270	798	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
10271	799	32	<i>Pseudomonas aeruginosa</i>
10275	800	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
10276	801	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
10277	802	33	<i>Homo sapiens</i>
10278	803	39	<i>Magnetospirillum magnetotacticum</i> ; <i>Geobacter metallireducens</i>
10279	804	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>

10515	805	33	<i>Azotobacter vinelandii</i> ; <i>Pseudomonas aeruginosa</i>
10572	806	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
10573	807	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
10574	808	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
10576	809	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
10578	810	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
10579	811	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
10580	812	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
10608	813	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
10715	814	41	<i>Magnetospirillum magnetotacticum</i> ; <i>Oryza sativa</i> ; <i>Homo sapiens</i> ; <i>Zea mays</i> ; <i>Mesorhizobium loti</i> ; <i>Azotobacter vinelandii</i> ; <i>Ralstonia solanacearum</i>
10719	815	60	<i>Desulfovibrio desulfuricans</i> ; <i>Rubrivivax gelatinosus</i> ; <i>Streptomyces coelicolor</i> ; <i>Pseudomonas putida</i> ; <i>Hepatitis E</i> ; <i>Rhodobacter sphaeroides</i> ; <i>Homo sapiens</i> ; <i>Chimpanzee cytomegalovirus</i>
10815	816	37	<i>Azotobacter vinelandii</i>
10816	817	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
10817	818	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
10818	819	33	<i>Pseudomonas fluorescens</i> ; <i>Bifidobacterium longum</i> ;
10819	820	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
10820	821	39	<i>Pseudomonas aeruginosa</i>
10821	822	129	<i>Nostoc punctiforme</i> ; <i>Novosphingobium aromaticivorans</i>
10822	823	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
10823	824	47	<i>Polyporaceae</i> sp.
10824	825	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
10826	826	33	<i>Pseudomonas aeruginosa</i>
10828	827	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
11048	828	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
11166	829	68	<i>Mycobacterium leprae</i> ; <i>Oryza sativa</i> ; <i>Mycobacterium tuberculosis</i> ; <i>Rattus norvegicus</i>
11303	830	41	<i>Burkholderia cepacia</i> ; <i>Halobacterium</i> sp. NRC-1; <i>Homo sapiens</i>
11321	831	48	<i>Rhodobacter sphaeroides</i> ; <i>Homo sapiens</i> ; <i>Desulfitobacterium hafniense</i> ; <i>Streptomyces coelicolor</i> ; <i>Deinococcus radiodurans</i> ; <i>Oryza sativa</i> ; <i>Streptomyces avermitilis</i> ; <i>Mesorhizobium loti</i> ; <i>Rhodopseudomonas palustris</i> ; <i>Ralstonia metallidurans</i> ; <i>Burkholderia fungorum</i> ; <i>Mycobacterium avium</i> (strain GIRO); <i>Ralstonia solanacearum</i>
11322	832	60	<i>Oryza sativa</i> ; <i>Homo sapiens</i> ; <i>Mesorhizobium loti</i> ; <i>Bovine herpesvirus</i> type 1; <i>Streptomyces coelicolor</i>
11540	833	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
11660	834	44	<i>Sus scrofa</i> ; <i>Mycobacterium smegmatis</i> ; <i>Homo sapiens</i> ; <i>Frankia</i> sp.; <i>Streptomyces atroolivaceus</i>
11824	835	39	<i>Streptomyces coelicolor</i> ; <i>Oryza sativa</i> ; <i>Streptomyces atroolivaceus</i> ; <i>Rhodobacter sphaeroides</i> ; <i>Rhodospirillum rubrum</i> ; <i>Halobacterium</i> sp. NRC-1
11827	836	37	<i>Rhodopseudomonas palustris</i> ; <i>Burkholderia fungorum</i>

11840	837	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
11841	838	54	<i>Thermobifida fusca</i>
11844	839	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
11896	840	68	<i>Mycobacterium tuberculosis</i> ; <i>Pseudomonas aeruginosa</i> ; <i>Magnetospirillum magnetotacticum</i> ; <i>Mus musculus</i>
12183	841	33	<i>Mus musculus</i>
12399	842	41	<i>Streptomyces griseus</i> ; <i>Oryza sativa</i> ; <i>Halobacterium</i> sp. NRC-1; <i>Pan troglodytes</i> ; <i>Chimpanzee cytomegalovirus</i> ; <i>Mesorhizobium loti</i> ; <i>Pseudomonas fluorescens</i> ; <i>Burkholderia fungorum</i> ; <i>Desulfitobacterium hafniense</i> ;
12436	843	56	<i>Azotobacter vinelandii</i> ; <i>Streptomyces coelicolor</i> ; <i>Rhodopseudomonas palustris</i> ; <i>Mesorhizobium loti</i>
12635	844	104	<i>Mycobacterium tuberculosis</i> ; <i>Burkholderia fungorum</i> ; <i>Drosophila melanogaster</i> ; <i>Azotobacter vinelandii</i> ; <i>Ralstonia solanacearum</i> ; <i>Sinorhizobium meliloti</i> ; <i>Oryza sativa</i> ; <i>Pseudomonas fluorescens</i> ; <i>Magnetospirillum magnetotacticum</i> ; <i>Zea mays</i> ; <i>Cervid herpesvirus</i>
13011	845	117	<i>Mycobacterium avium</i> (strain 2151)
13013	846	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13015	847	116	<i>Mycobacterium avium</i> (strain 2151); <i>Streptomyces coelicolor</i> ; <i>Homo sapiens</i> ; <i>Magnetospirillum magnetotacticum</i>
13016	848	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13017	849	68	<i>Mycobacterium avium</i> (strain 2151)
13129	850	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13130	851	42	<i>Thermobifida fusca</i>
13137	852	37	<i>Papio anubis</i> ; <i>Streptomyces coelicolor</i>
13138	853	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13139	854	39	<i>Rhodopseudomonas palustris</i> ; <i>Burkholderia fungorum</i> ; <i>Pseudomonas putida</i>
13140	855	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13141	856	33	<i>Mycobacterium smegmatis</i>
13142	857	32	<i>Desulfitobacterium hafniense</i>
13143	858	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13144	859	32	<i>Pseudomonas fluorescens</i>
13147	860	37	<i>Oryza sativa</i>
13148	861	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13149	862	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13150	863	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13151	864	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13152	865	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13153	866	37	<i>Oryza sativa</i>
13154	867	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13155	868	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13156	869	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13157	870	32	<i>Streptomyces coelicolor</i>
13158	871	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13159	872	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13160	873	32	<i>Streptomyces coelicolor</i>

13161	874	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13162	875	37	<i>Myxococcus xanthus</i>
13167	876	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13168	877	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13169	878	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13170	879	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13171	880	32	<i>Mesorhizobium loti</i>
13172	881	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13175	882	36	<i>Streptomyces coelicolor</i>
13176	883	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13177	884	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13178	885	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13179	886	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13180	887	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13181	888	32	<i>Magnetospirillum magnetotacticum</i>
13182	889	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13183	890	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13184	891	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13188	892	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13189	893	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13190	894	39	<i>Rhodopseudomonas palustris</i>
13191	895	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13192	896	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13193	897	32	<i>S.cerevisiae</i>
13194	898	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13195	899	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13196	900	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13197	901	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13198	902	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13202	903	32	<i>Oryza sativa</i>
13203	904	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13204	905	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13205	906	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13206	907	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13207	908	32	<i>Ralstonia solanacearum</i>
13208	909	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13212	910	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13490	911	99	<i>Mycobacterium tuberculosis</i> ; <i>Mycobacterium bovis</i>
13522	912	101	<i>Mycobacterium tuberculosis</i> ; <i>Mycobacterium leprae</i> ; <i>Ralstonia solanacearum</i> ; <i>Streptomyces coelicolor</i> ; <i>Caulobacter crescentus</i> ; <i>Homo sapiens</i> ; <i>Pseudomonas fluorescens</i> ; <i>Streptomyces caelestis</i> ; <i>Amycolatopsis mediterranei</i> ; <i>Zea mays</i>
13563	913	80	<i>Mycobacterium tuberculosis</i> ; <i>Mycobacterium leprae</i> ; <i>Thermobifida fusca</i> ; <i>Chlorobium tepidum</i> ; <i>Treponema medium</i> ; <i>Spirochete</i> ; <i>Treponema denticola</i> ; <i>Chloroflexus aurantiacus</i> ; <i>Clostridium thermocellum</i> ; <i>Micrococcus luteus</i> ; <i>Deinococcus radiodurans</i> ; <i>Mycobacterium phage</i> Ms6; <i>Synechococcus sp.</i>

13564	914	42	<i>Chlorobium tepidum</i> ; <i>Mesorhizobium loti</i> ; <i>Sinorhizobium meliloti</i>
13616	915	107	<i>Mycobacterium leprae</i> ; <i>Mycobacterium tuberculosis</i> ; <i>Streptomyces coelicolor</i> ; Bovine herpesvirus type 1; <i>Lymantria dispar</i> ;
13718	916	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13719	917	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13720	918	32	<i>Homo sapiens</i> ; <i>Azotobacter vinelandii</i>
13721	919	44	<i>Oryza sativa</i> ; <i>Streptomyces coelicolor</i>
13723	920	32	<i>Mesorhizobium loti</i>
13724	921	37	<i>Escherichia coli</i> ; <i>Klebsiella pneumoniae</i> ; <i>Streptomyces coelicolor</i> ; <i>Enterobacter aerogenes</i>
13725	922	50	<i>Streptomyces noursei</i>
13726	923	39	<i>Methylobacterium extorquens</i> ; <i>Homo sapiens</i> ; <i>Deinococcus radiodurans</i>
13727	924	37	<i>Burkholderia fungorum</i> ; <i>Desulfitobacterium hafniense</i> ; <i>Brucella abortus</i> ; <i>Brucella melitensis</i> ; <i>Brucella suis</i>
13728	925	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13729	926	44	<i>Pseudomonas fluorescens</i> ;
13730	927	33	<i>Streptomyces coelicolor</i>
13731	928	32	<i>Rhodopseudomonas palustris</i> ; <i>Oryza sativa</i>
13732	929	44	<i>Thermosynechococcus elongatus</i>
13733	930	37	<i>Rhodospirillum rubrum</i> ; <i>Ralstonia solanacearum</i> ; <i>Amycolatopsis mediterranei</i>
13735	931	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13740	932	41	<i>Desulfitobacterium hafniense</i> ; <i>Azotobacter vinelandii</i> ; <i>Magnetospirillum magnetotacticum</i> ; <i>Caulobacter crescentus</i> ; <i>Pseudomonas aeruginosa</i>
13741	933	44	<i>Homo sapiens</i>
13743	934	36	<i>Rhodopseudomonas palustris</i> ; <i>Microbulbifer degradans</i> ; <i>Deinococcus radiodurans</i>
13744	935	39	<i>Homo sapiens</i> ; <i>Ralstonia metallidurans</i>
13745	936	44	<i>Chromobacterium violaceum</i> ; <i>Thermobifida fusca</i> ; <i>Sinorhizobium meliloti</i> ; <i>Rhodospirillum rubrum</i> ; <i>Pseudomonas syringae</i> pv. <i>syringae</i> ; <i>Rhizobium meliloti</i> (<i>Sinorhizobium meliloti</i>); <i>Homo sapiens</i>
13746	937	39	<i>Ralstonia solanacearum</i> ; <i>Xanthomonas axonopodis</i> ; <i>Novosphingobium aromaticivorans</i>
13747	938	32	<i>Saccharomyces cerevisiae</i> ; <i>Ralstonia solanacearum</i>
13748	939	33	<i>Mycobacterium tuberculosis</i> ; <i>Amycolatopsis lactamdurans</i>
13749	940	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13750	941	37	<i>Pseudomonas aeruginosa</i> ; <i>Sinorhizobium meliloti</i> ;
13751	942	44	<i>Streptomyces coelicolor</i> ; Bovine herpesvirus type 1; <i>Deinococcus radiodurans</i>
13752	943	50	<i>Rhodobacter sphaeroides</i> ; <i>Rhodopseudomonas palustris</i> ; <i>Rhodospirillum rubrum</i> ; <i>Azotobacter vinelandii</i> ; <i>Micromonospora megalomicea</i> subsp. <i>nigra megalomicin</i> ; <i>Agrobacterium tumefaciens</i> ; <i>Homo sapiens</i>
13753	944	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>

13754	945	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13755	946	38	<i>Rubrivivax gelatinosus</i> ; <i>Ralstonia eutropha</i>
13756	947	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13757	948	38	<i>Homo sapiens</i>
13758	949	31	<i>Homo sapiens</i>
13759	950	37	<i>Pseudomonas fluorescens</i> ; <i>Pseudomonas syringae</i> ; <i>Pseudomonas aeruginosa</i>
13760	951	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13762	952	77	<i>Streptomyces</i> sp.; <i>Streptomyces coelicolor</i> ; <i>Chloroflexus aurantiacus</i> ; <i>Deinococcus radiodurans</i> ; <i>Pseudomonas putida</i>
13763	953	33	<i>Rhodopseudomonas palustris</i> ; <i>Desulfitobacterium hafniense</i>
13764	954	33	<i>Oryctolagus cuniculus</i>
13765	955	33	<i>Streptomyces hygroscopicus</i>
13766	956	37	<i>Magnetospirillum magnetotacticum</i> ; <i>Streptomyces coelicolor</i> ; <i>Homo sapiens</i>
13767	957	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13768	958	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13769	959	37	<i>Oryza sativa</i> ; <i>Mesorhizobium loti</i> ; <i>Magnetospirillum magnetotacticum</i>
13770	960	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13771	961	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13772	962	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
13773	963	45	<i>Streptomyces coelicolor</i> ; <i>Amycolatopsis mediterranei</i> ; <i>Rhodopseudomonas palustris</i> ; <i>Rhodospirillum rubrum</i> ; <i>Homo sapiens</i> ; <i>Brucella melitensis</i> ; <i>Papio anubis</i> ; <i>Sus scrofa</i> ; <i>Brucella suis</i>
13774	964	32	<i>Pseudomonas aeruginosa</i>
13776	965	54	<i>Mycobacterium tuberculosis</i> ; <i>Homo sapiens</i> ; <i>Bordetella bronchiseptica</i>
13777	966	44	<i>Oryza sativa</i> ; <i>Homo sapiens</i> ; <i>Streptomyces coelicolor</i> ; <i>Triticum aestivum</i> ; <i>Hordeum vulgare</i> ; <i>Bos taurus</i> ; <i>Mus musculus</i>
14004	967	47	<i>Desulfitobacterium hafniense</i> ; <i>Oryza sativa</i> ; <i>Homo sapiens</i> ; <i>M. bovis</i> ; <i>Streptomyces griseus</i> ; <i>Streptomyces coelicolor</i> ; <i>Chlamydomonas reinhardtii</i> ; <i>Pseudomonas putida</i>
14278	968	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
14279	969	32	<i>Ralstonia metallidurans</i>
14280	970	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
14294	971	33	<i>Deinococcus radiodurans</i> ; <i>Streptomyces spheroides</i> ; <i>Ralstonia solanacearum</i> ; <i>Streptomyces coelicolor</i>
14301	972	50	<i>Homo sapiens</i> ; <i>Gallus gallus</i> ; <i>Mycobacterium tuberculosis</i> ; <i>Rhodospirillum rubrum</i> ; <i>Magnetospirillum magnetotacticum</i> ; <i>Geobacter metallireducens</i> ; <i>Desulfitobacterium hafniense</i> ; <i>Streptomyces coelicolor</i>
14546	973	68	<i>Mycobacterium tuberculosis</i> ; <i>Homo sapiens</i> ; <i>Erwinia chrysanthemi</i> ; <i>Streptomyces coelicolor</i> ; <i>Xanthomonas</i>

			<i>nopodis</i> ; <i>Streptomyces avermitilis</i> ; <i>Alcaligenes eutrophus</i> ; <i>Desulfotobacterium hafniense</i> ; <i>Oryza sativa</i> ; <i>Salmonella enterica</i> ; <i>Struthio camelus</i> ; <i>Salmonella typhimurium</i>
14659	974	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
14661	975	33	<i>Homo sapiens</i> ; <i>Escherichia coli</i>
14757	976	59	<i>Oryza sativa</i> ; <i>Chlamydomonas reinhardtii</i> ; <i>Homo sapiens</i> ; <i>Mesorhizobium loti</i> ; <i>Magnetospirillum magnetotacticum</i> ; <i>Mycobacterium xenopi</i> ; <i>Neisseria meningitidis</i> ; <i>Sinorhizobium meliloti</i> ; <i>Streptomyces coelicolor</i> ; <i>Myxococcus xanthus</i> ;
14792	977	44	<i>Oryza sativa</i> ; <i>Streptomyces coelicolor</i> ; <i>Corynebacterium efficiens</i> ; <i>Myxococcus xanthus</i> ; <i>Pyrobaculum aerophilum</i>
14903	978	32	<i>Mus musculus</i>
14929	979	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
14930	980	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
14931	981	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
14934	982	33	<i>Mesorhizobium loti</i> ; <i>Rhodobacter sphaeroides</i>
14935	983	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
14936	984	39	<i>Bacillus halodurans</i>
14979	985	44	<i>Mycobacterium tuberculosis</i> ; <i>Caenorhabditis briggsae</i>
15007	986	41	<i>Oryza sativa</i> ; <i>Homo sapiens</i>
15025	987	50	<i>Oryza sativa</i> ; <i>Streptomyces coelicolor</i> ; <i>Caenorhabditis briggsae</i>
15056	988	65	<i>Mycobacterium tuberculosis</i> ; <i>Xanthomonas campestris</i>
15057	989	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
15058	990	33	<i>Leishmania major</i>
15059	991	53	<i>Mycobacterium tuberculosis</i> ; <i>Homo sapiens</i>
15109	992	38	<i>Mus musculus</i> ; <i>Homo sapiens</i>
15132	993	98	<i>Mycobacterium tuberculosis</i> ; <i>Mycobacterium leprae</i> ; <i>Chlorobium tepidum</i> ; <i>Halobacterium</i> sp.; <i>Rhodospirillum rubrum</i> ; <i>Pseudomonas syringae</i> ; <i>Streptomyces coelicolor</i> ; <i>Pseudomonas putida</i> ; <i>Leishmania major</i> ; <i>Brucella melitensis</i> ; <i>Brucella suis</i> ; <i>Rhodobacter sphaeroides</i> ; <i>Sinorhizobium meliloti</i> ; <i>Deinococcus radiodurans</i> ; <i>Neurospora crassa</i>
15258	994	59	<i>Mycobacterium tuberculosis</i> ; <i>Oryza sativa</i> ; <i>Molluscum contagiosum</i> ; <i>Rhodopseudomonas palustris</i> ; <i>Mycobacterium bovis</i> ; <i>Mus musculus</i> ; <i>Magnetospirillum magnetotacticum</i>
15305	995	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
15306	996	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
15307	997	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
15308	998	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
15309	999	32	<i>Mesorhizobium loti</i> ; <i>Rhodopseudomonas palustris</i> ; <i>Ralstonia solanacearum</i>
15311	1000	33	<i>Mesorhizobium loti</i>
15312	1001	39	<i>Bacillus halodurans</i>
15313	1002	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
15343	1003	100	<i>Mycobacterium tuberculosis</i> ; <i>Magnetospirillum</i>

			<i>magnetotacticum</i> ; <i>Azotobacter vinelandii</i> ; <i>Ralstonia solanacearum</i> ; <i>Pseudomonas fluorescens</i> ; <i>Ralstonia metallidurans</i> ; <i>Magnetococcus</i> sp.; <i>Desulfovibrio desulfuricans</i> ; <i>Brucella melitensis</i> ; <i>Brucella suis</i>
15408	1004	47	<i>Azotobacter vinelandii</i> ; <i>Mycobacterium tuberculosis</i>
15461	1005	33	<i>Oryza sativa</i> ; <i>Desulfitobacterium hafniense</i> ; <i>Streptomyces collinus</i> ; <i>Aphis gossypii</i>
15682	1006	62	<i>Chlamydomonas reinhardtii</i> ; <i>Homo sapiens</i> ; <i>Mycobacterium tuberculosis</i> ; <i>Mycobacterium leprae</i> ; <i>Mus musculus</i> ; <i>Magnetospirillum magnetotacticum</i> ; <i>Sinorhizobium meliloti</i> ; <i>Tetradon nigroviridis</i>
15685	1007	113	<i>Mycobacterium tuberculosis</i> ; <i>Streptomyces</i> sp.; <i>Oryza sativa</i> ; <i>Streptomyces griseus</i> ; <i>Halobacterium</i> sp.; <i>Homo sapiens</i> ; <i>Pseudomonas fluorescens</i> ; <i>Novosphingobium aromaticivorans</i> ; <i>Synechococcus</i> sp.; <i>Drosophila melanogaster</i> ; <i>Streptomyces coelicolor</i>
15783	1008	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
15784	1009	39	<i>Bacillus halodurans</i>
15785	1010	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
15787	1011	32	<i>Mesorhizobium loti</i> ; <i>Rhodopseudomonas palustris</i> ; <i>Ralstonia solanacearum</i>
15788	1012	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
15789	1013	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
15790	1014	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
15791	1015	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
15959	1016	32	<i>Sinorhizobium meliloti</i> ; <i>Halobacterium</i> sp.
16477	1017	38	<i>Rhodobacter sphaeroides</i> ; <i>Ralstonia solanacearum</i> ; <i>Streptomyces coelicolor</i>
16614	1018	78	<i>Mycobacterium tuberculosis</i> ; <i>Mycobacterium leprae</i> ; <i>Xanthomonas campestris</i>
16697	1019	69	<i>Oryza sativa</i> ; <i>Homo sapiens</i> ; <i>Spermatozopsis similis</i> ; <i>Pseudorabies virus</i> ; <i>Magnetospirillum magnetotacticum</i> ; <i>Triticum aestivum</i>
16838	1020	47	<i>Streptomyces verticillus</i> ; <i>Frankia</i> sp.; <i>Streptomyces atroolivaceus</i> ; <i>Ralstonia solanacearum</i> ; <i>Mycobacterium tuberculosis</i> ; <i>Oryza sativa</i> ; <i>Desulfitobacterium hafniense</i> ; <i>Streptomyces coelicolor</i> ; <i>Halobacterium</i> sp.; <i>Xanthomonas campestris</i> ; <i>Homo sapiens</i> ; <i>Caulobacter crescentus</i> ; <i>Rhodospirillum rubrum</i> ; <i>Magnetospirillum magnetotacticum</i> ; <i>Rattus norvegicus</i> ; <i>Oryza sativa</i> ; <i>Ralstonia solanacearum</i> ; <i>Bovine adenovirus</i>
17028	1021	60	<i>Mycobacterium tuberculosis</i> ; <i>Oryza sativa</i> ; <i>Streptomyces coelicolor</i> ; <i>Streptomyces avermitilis</i> ; <i>Xanthomonas campestris</i> ; <i>Drosophila melanogaster</i> ; <i>Homo sapiens</i> ; <i>Thermobifida fusca</i>
17153	1022	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17154	1023	39	<i>Oryza sativa</i> ; <i>Ralstonia metallidurans</i> ; <i>Pseudomonas putida</i>
17155	1024	38	<i>Rhodobacter sphaeroides</i> ; <i>Ralstonia metallidurans</i> ; <i>Zea</i>

			<i>mays</i>
17156	1025	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17157	1026	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17158	1027	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17159	1028	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17160	1029	35	<i>Halobacterium</i> sp.; <i>Corynebacterium efficiens</i> ; <i>Magnetospirillum magnetotacticum</i> ; <i>Oryza sativa</i>
17161	1030	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17162	1031	33	<i>Streptomyces avermitilis</i>
17163	1032	53	<i>Mycobacterium tuberculosis</i>
17164	1033	86	<i>Mycobacterium tuberculosis</i> ; <i>Oryza sativa</i>
17165	1034	32	<i>Ralstonia solanacearum</i>
17166	1035	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17167	1036	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17168	1037	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17169	1038	33	<i>Ralstonia solanacearum</i>
17170	1039	38	<i>Oryza sativa</i>
17171	1040	44	<i>Ralstonia metallidurans</i> ; <i>Deinococcus radiodurans</i>
17172	1041	32	<i>Drosophila melanogaster</i>
17173	1042	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17174	1043	53	<i>Mycobacterium tuberculosis</i>
17175	1044	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17176	1045	41	<i>Arabidopsis thaliana</i> ; <i>Xanthomonas campestris</i>
17177	1046	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17179	1047	38	<i>Azotobacter vinelandii</i> ; <i>Xanthomonas campestris</i>
17181	1048	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17182	1049	38	<i>Triticum aestivum</i> ; <i>Mus musculus</i>
17183	1050	35	<i>Methylobacterium extorquens</i>
17184	1051	32	<i>Oryza sativa</i>
17185	1052	38	<i>Mesorhizobium loti</i>
17187	1053	47	<i>Streptomyces coelicolor</i> ; <i>Rhodopseudomonas palustris</i>
17188	1054	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17191	1055	36	<i>Rhodobacter capsulatus</i>
17192	1056	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17193	1057	32	<i>Burkholderia fungorum</i>
17194	1058	32	<i>Streptomyces coelicolor</i> ; <i>Drosophila melanogaster</i>
17195	1059	44	<i>Burkholderia fungorum</i> ; <i>S. erythraea</i> ; <i>Xanthomonas axonopodis</i>
17196	1060	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17197	1061	32	<i>Homo sapiens</i>
17198	1062	39	<i>Oryza sativa</i>
17199	1063	45	<i>Methanopyrus kandleri</i>
17200	1064	38	<i>Thermobifida fusca</i>
17201	1065	44	<i>Rhodopseudomonas palustris</i> ; <i>Desulfonatronum lacustre</i>
17202	1066	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17203	1067	38	<i>Rhodobacter sphaeroides</i> ; <i>Homo sapiens</i> ; <i>Sphingomonas paucimobilis</i> ; <i>Caulobacter crescentus</i> ;
17204	1068	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17205	1069	38	<i>Oryza sativa</i> ; <i>Novosphingobium aromaticivorans</i> ;

			<i>Pseudomonas putida</i>
17206	1070	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17207	1071	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17208	1072	32	<i>Homo sapiens</i>
17209	1073	62	<i>Streptomyces coelicolor</i> ; <i>Pseudomonas aeruginosa</i> ; <i>Ralstonia metallidurans</i> ; <i>Magnetospirillum magnetotacticum</i> ; <i>Azoarcus evansii</i> ; <i>Rhodobacter sphaeroides</i> ; <i>Halobacterium</i> sp.; <i>Streptomyces collinus</i> ; <i>Caulobacter crescentus</i>
17210	1074	44	<i>Rhodopseudomonas palustris</i> ; <i>Mycobacterium leprae</i> ; <i>Pseudomonas fluorescens</i> ; <i>Sinorhizobium meliloti</i> ; <i>Streptomyces coelicolor</i> ; <i>Xanthomonas campestris</i> ; <i>Micromonospora echinospora</i> ; <i>H. salinarium</i> ; <i>Mesorhizobium loti</i> ; <i>Novosphingobium aromaticivorans</i> ; <i>Mycobacterium tuberculosis</i> ; <i>Agrobacterium tumefaciens</i>
17211	1075	32	<i>Ralstonia solanacearum</i>
17212	1076	68	<i>Shigella flexneri</i> ; <i>Escherichia coli</i> ; <i>Prochlorococcus marinus</i> ; <i>Magnetospirillum magnetotacticum</i> ; <i>Rhodopseudomonas palustris</i> ; <i>Burkholderia fungorum</i> ; <i>Thermobifida fusca</i> ; <i>Streptomyces coelicolor</i>
17213	1077	59	<i>Rhodopseudomonas palustris</i> ; <i>Pseudomonas aeruginosa</i> ; <i>Burkholderia fungorum</i> ; <i>Novosphingobium aromaticivorans</i> ; <i>Streptomyces</i> sp.; <i>Amycolatopsis mediterranei</i> ; <i>Streptomyces coelicolor</i> ; <i>Halobacterium</i> sp.; <i>Pseudomonas putida</i> ; <i>Oryza sativa</i> ; <i>Micromonospora megalomicea</i> (subsp. <i>nigra megalomycin</i>); <i>Zea mays</i>
17214	1078	44	<i>Novosphingobium aromaticivorans</i> ; <i>Magnetospirillum magnetotacticum</i> ; <i>Rhodopseudomonas palustris</i> ; <i>Thermobifida fusca</i> ; <i>Thauera aromatica</i> ; <i>Caulobacter crescentus</i>
17215	1079	32	<i>Deinococcus radiodurans</i>
17216	1080	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17217	1081	51	<i>Mesorhizobium loti</i> ; <i>Burkholderia fungorum</i>
17218	1082	44	<i>Ralstonia solanacearum</i> ; <i>Hordeum vulgare</i> ; <i>Ralstonia metallidurans</i> ; <i>Xanthomonas axonopodis</i> ; <i>Caulobacter crescentus</i> ; <i>Burkholderia fungorum</i> ; <i>Streptomyces antibioticus</i> ; <i>Corynebacterium efficiens</i> ; <i>Xanthomonas campestris</i> ; <i>Zea mays</i>
17219	1083	62	<i>Mesorhizobium loti</i> ; <i>Ralstonia metallidurans</i> ; <i>Desulfotobacterium hafniense</i> ; <i>Agrobacterium tumefaciens</i>
17220	1084	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17221	1085	60	<i>Chlorobium tepidum</i> ; <i>Pseudomonas fluorescens</i> ; <i>Ralstonia metallidurans</i> ; <i>Burkholderia fungorum</i> ; <i>Mycobacterium tuberculosis</i> ; <i>Streptomyces lavendulae</i> ; <i>Novosphingobium aromaticivorans</i> ; <i>Ralstonia solanacearum</i> ; <i>Streptomyces coelicolor</i> ; <i>Oryza sativa</i> ; <i>Xanthomonas axonopodis</i> ; <i>Pseudomonas aeruginosa</i>
17222	1086	33	<i>Mycobacterium tuberculosis</i>
17223	1087	38	<i>Lymantria dispar</i> nucleopolyhedrovirus
17224	1088	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>

17225	1089	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17226	1090	50	<i>Streptomyces griseus</i>
17227	1091	35	<i>Ralstonia metallidurans</i>
17228	1092	60	<i>Mesorhizobium loti</i> ; <i>Azotobacter vinelandii</i> ; <i>Streptomyces coelicolor</i> ; <i>Homo sapiens</i>
17229	1093	41	<i>Brucella melitensis</i> ; <i>Brucella suis</i>
17230	1094	53	<i>Burkholderia fungorum</i> ; <i>Ralstonia solanacearum</i>
17231	1095	47	<i>Thermobifida fusca</i> ; <i>Oryza sativa</i>
17232	1096	45	<i>Novosphingobium aromaticivorans</i> ; <i>Streptomyces coelicolor</i> ; <i>Mesorhizobium loti</i> ; <i>Sinorhizobium meliloti</i> ;
17233	1097	33	<i>Homo sapiens</i>
17234	1098	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17235	1099	62	<i>Caulobacter crescentus</i> ; <i>Magnetospirillum magnetotacticum</i> ; <i>Streptomyces coelicolor</i>
17236	1100	32	<i>Sinorhizobium meliloti</i>
17237	1101	38	<i>Saccharopolyspora erythraea</i>
17238	1102	32	<i>Leishmania major</i>
17241	1103	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17242	1104	53	<i>Streptomyces coelicolor</i> ; <i>Burkholderia fungorum</i>
17243	1105	36	<i>Ralstonia solanacearum</i> ; <i>Thermobifida fusca</i>
17244	1106	50	<i>Oryza sativa</i>
17245	1107	32	<i>Sinorhizobium meliloti</i> ; <i>Rhizobium</i> sp.
17246	1108	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17247	1109	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17248	1110	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17249	1111	39	<i>Streptomyces coelicolor</i> ; <i>Lactococcus lactis</i> subsp. <i>Lactis</i>
17264	1112	75	<i>Mycobacterium tuberculosis</i> ; <i>Desulfitobacterium hafniense</i> ; <i>Ralstonia solanacearum</i> ; <i>Streptomyces coelicolor</i> ; <i>Mesorhizobium loti</i> ; <i>Homo sapiens</i> ; <i>Rhodospirillum rubrum</i> ; <i>Ralstonia metallidurans</i> ; <i>Xylella fastidiosa</i> ; <i>Azotobacter vinelandii</i> ; <i>Prochlorococcus marinus</i> ; <i>Oryza sativa</i> ; <i>Sinorhizobium meliloti</i>
17284	1113	38	<i>Ralstonia solanacearum</i> ; <i>Streptomyces coelicolor</i> ; <i>Chimpanzee cytomegalovirus</i>
17366	1114	50	<i>Magnetospirillum magnetotacticum</i> ; <i>Azotobacter vinelandii</i> ; <i>Homo sapiens</i> ; <i>Ralstonia solanacearum</i> ; <i>Streptomyces coelicolor</i> ; <i>Oryza sativa</i>
17403	1115	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17404	1116	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17406	1117	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17407	1118	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17408	1119	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17409	1120	32	<i>Homo sapiens</i>
17410	1121	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17419	1122	33	<i>Azotobacter vinelandii</i>
17420	1123	71	<i>Corynebacterium efficiens</i> ; <i>Bifidobacterium longum</i> ; <i>Mycobacterium avium</i> (strain 2151)
17421	1124	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17422	1125	48	<i>Streptomyces lividans</i> ; <i>Mycobacterium tuberculosis</i> ;

			<i>Burkholderia fungorum</i> ; <i>Zea mays</i>
17424	1126	56	<i>Renibacterium salmoninarum</i>
17425	1127	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17426	1128	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17427	1129	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17428	1130	32	<i>Pseudomonas syringae</i> ; <i>Desulfitobacterium hafniense</i>
17429	1131	38	<i>Rhodopseudomonas palustris</i>
17430	1132	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17434	1133	38	<i>Thermus equiperdum</i>
17437	1134	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17438	1135	32	<i>Desulfovibrio desulfuricans</i>
17439	1136	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17440	1137	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17441	1138	32	<i>Homo sapiens</i>
17442	1139	38	<i>Neurospora crassa</i>
17443	1140	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17444	1141	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17445	1142	33	<i>Escherichia coli</i>
17449	1143	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17457	1144	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17458	1145	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17459	1146	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17460	1147	38	<i>Magnetospirillum magnetotacticum</i>
17461	1148	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17462	1149	32	<i>Rhodopseudomonas palustris</i>
17463	1150	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17464	1151	32	<i>Mastigamoeba balamuthi</i>
17465	1152	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17466	1153	33	<i>Homo sapiens</i> ; <i>Neurospora crassa</i> ; <i>Bifidobacterium longum</i> ; <i>Sinorhizobium meliloti</i>
17467	1154	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17707	1155	45	<i>Halobacterium salinarum</i> ; <i>Magnetospirillum magnetotacticum</i> ; <i>Halobacterium</i> sp.; <i>Rhodopseudomonas palustris</i> ; <i>Rhodospirillum rubrum</i> ; <i>Streptomyces fradiae</i> ; <i>Zea mays</i>
17835	1156	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17837	1157	92	<i>Mycobacterium tuberculosis</i>
17882	1158	51	<i>Agaricus bisporus</i> ; <i>Yersinia pestis</i>
17883	1159	33	<i>Oryza sativa</i>
17884	1160	39	<i>Streptomyces coelicolor</i>
17885	1161	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17893	1162	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
17935	1163	75	<i>Mycobacterium tuberculosis</i> ; <i>Burkholderia fungorum</i> ; <i>Drosophila melanogaster</i> ; <i>Thermobifida fusca</i> ; <i>Streptomyces clavuligerus</i>
17946	1164	59	<i>Drosophila melanogaster</i> ; <i>Mycobacterium tuberculosis</i> ; <i>Streptomyces coelicolor</i>
17959	1165	38	<i>Oryza sativa</i> ; <i>Deinococcus radiodurans</i> ; <i>Ralstonia solanacearum</i> ; <i>Streptomyces coelicolor</i>

18067	1166	84	<i>Mycobacterium avium</i> (strain 2151)
18069	1167	100	<i>Mycobacterium avium</i> (strain 2151); <i>Streptomyces coelicolor</i> ; <i>Magnetospirillum magnetotacticum</i>
18070	1168	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
18071	1169	68	<i>Mycobacterium avium</i> (strain 2151)
18182	1170	50	<i>Mycobacterium avium</i> ; <i>Pseudomonas fluorescens</i> ; <i>Oryza sativa</i> ; <i>Pseudomonas putida</i>
18183	1171	270	<i>Mycobacterium avium</i>
18189	1172	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
18190	1173	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
18191	1174	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
18192	1175	51	<i>Neurospora crassa</i>
18193	1176	36	<i>Drosophila melanogaster</i> ; <i>Halobacterium</i> sp.
18194	1177	38	<i>Homo sapiens</i>
18195	1178	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
18258	1179	47	<i>Leishmania major</i> ; <i>Oryza sativa</i> ; <i>Pseudomonas fluorescens</i> ; <i>Homo sapiens</i> ; <i>Rhodobacter sphaeroides</i> ; <i>Brucella melitensis</i> ; <i>Brucella suis</i> ; <i>Zea mays</i>
18562	1180	45	<i>Neisseria meningitidis</i> ; <i>Streptomyces viridochromogenes</i>
18564	1181	65	<i>Mycobacterium tuberculosis</i> ; <i>Mus musculus</i> ; <i>Pseudorabies virus</i> ; <i>Mycobacterium leprae</i> ; <i>Caenorhabditis briggsae</i>
18590	1182	63	<i>Mycobacterium tuberculosis</i> ; <i>Mycobacterium bovis</i>
18592	1183	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
18593	1184	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
18594	1185	77	<i>Mycobacterium tuberculosis</i> ; <i>Streptomyces coelicolor</i> ; <i>Micromonospora megalomicea</i> subsp. <i>nigra megalomicin</i>
18608	1186	44	<i>Mycobacterium leprae</i> ; <i>Rhodopseudomonas palustris</i>
18700	1187	86	<i>Mycobacterium tuberculosis</i> ; <i>Mycobacterium leprae</i> ; <i>Oryza sativa</i> ; <i>Rhodospirillum rubrum</i> ; <i>Magnetospirillum magnetotacticum</i> ; <i>Zea mays</i> ; <i>Streptomyces griseus</i> ; <i>Homo sapiens</i>
18728	1188	32	<i>Mus musculus</i>
18748	1189	50	<i>Homo sapiens</i> ; <i>Magnetospirillum magnetotacticum</i> ; <i>Rattus norvegicus</i> ; <i>Oryctolagus cuniculus</i> ; <i>Mycobacterium leprae</i> ; <i>Oryza sativa</i> ; <i>Mus musculus</i>
18833	1190	38	<i>Magnetospirillum magnetotacticum</i> ; <i>Mus musculus</i> ; <i>Homo sapiens</i> ; <i>Rhodopseudomonas palustris</i> ; <i>Caulobacter crescentus</i>
19342	1191	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
19343	1192	35	<i>Acetobacter xylinus</i>
19344	1193	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
19345	1194	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
19346	1195	75	<i>Mycobacterium tuberculosis</i> ; <i>Chlamydomonas reinhardtii</i> ; <i>Burkholderia fungorum</i> ; <i>Corynebacterium efficiens</i>
19348	1196	71	<i>Ralstonia</i> sp.; <i>Ralstonia metallidurans</i> ; <i>Bifidobacterium longum</i>
19364	1197	33	<i>Sus scrofa</i> ; <i>Saimiri sciureus</i> ; <i>Bos taurus</i>
19367	1198	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
19368	1199	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>

19369	1200	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
19370	1201	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
19499	1202	75	<i>Mycobacterium tuberculosis</i> ; <i>Burkholderia fungorum</i> ; <i>Acetobacter vinelandii</i> ; <i>Pseudomonas aeruginosa</i> ; <i>Salmonella enterica</i> ; <i>Salmonella typhi</i>
19753	1203	33	<i>Oryza sativa</i> ; <i>Trichomonas vaginalis</i>
19777	1204	45	<i>Rhodospirillum rubrum</i>
19892	1205	38	<i>Streptomyces coelicolor</i>
19893	1206	44	<i>Magnetospirillum magnetotacticum</i> ; <i>Homo sapiens</i> ; <i>Rhodospirillum rubrum</i> ; <i>Chloroflexus aurantiacus</i>
19894	1207	38	<i>Mesorhizobium loti</i> ; <i>Pseudomonas syringae</i>
19895	1208	45	<i>Streptomyces virginiae</i>
19896	1209	32	<i>Mus musculus</i>
19897	1210	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
19899	1211	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
19900	1212	33	<i>Microbispora bispora</i>
19901	1213	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
19902	1214	32	<i>Burkholderia fungorum</i> ; <i>Oryza sativa</i>
19903	1215	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
19922	1216	44	<i>Ralstonia solanacearum</i> ; <i>Rhodobacter sphaeroides</i> ; <i>Xanthomonas campestris</i> ; <i>Streptomyces avermitilis</i> ; <i>Sphingomonas paucimobilis</i> ; <i>Streptomyces coelicolor</i>
19923	1217	32	<i>Homo sapiens</i>
19924	1218	35	<i>Streptomyces coelicolor</i>
19925	1219	32	<i>Equine encephalosis virus 5</i>
19926	1220	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
19927	1221	32	<i>Triticum aestivum</i>
19928	1222	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
19929	1223	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
19931	1224	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
19932	1225	38	<i>Rhodobacter sphaeroides</i>
19933	1226	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
19934	1227	32	<i>Magnetospirillum magnetotacticum</i>
19935	1228	44	<i>Drosophila melanogaster</i>
19936	1229	75	<i>Desulfitobacterium hafniense</i> ; <i>Azotobacter vinelandii</i> ; <i>Pseudomonas fluorescens</i> ; <i>Leishmania major</i>
19937	1230	32	<i>Neisseria meningitidis</i>
19938	1231	51	<i>Desulfitobacterium hafniense</i> ; <i>Burkholderia fungorum</i>
19939	1232	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
19940	1233	33	<i>Drosophila melanogaster</i>
19941	1234	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
19958	1235	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
19959	1236	50	<i>Brucella abortus</i> ; <i>Brucella melitensis</i> ; <i>Brucella suis</i> ; <i>Caenorhabditis elegans</i>
19960	1237	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
19961	1238	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
19962	1239	32	<i>Salmonella enterica</i> ; <i>Salmonella typhimurium</i>
19963	1240	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
19964	1241	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>

19965	1242	32	<i>Novosphingobium aromaticivorans</i>
19966	1243	32	<i>Rhodobacter sphaeroides</i> ; <i>Drosophila melanogaster</i>
19967	1244	32	<i>Amycolatopsis orientalis</i>
19968	1245	38	<i>Homo sapien</i>
19969	1246	32	<i>Rhodopseudomonas palustris</i>
19970	1247	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
19971	1248	65	<i>Desulfitobacterium hafniense</i> ; <i>Streptomyces coelicolor</i> ; <i>Hordeum vulgare</i> ; <i>Thauera aromatica</i> ; <i>Mesorhizobium loti</i> ; <i>Ralstonia solanacearum</i> ; <i>Xanthomonas campestris</i> ; <i>Pseudomonas aeruginosa</i>
19972	1249	44	<i>Mesorhizobium loti</i> ; <i>Rhodobacter sphaeroides</i>
19973	1250	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
19974	1251	32	<i>Desulfitobacterium hafniense</i>
19975	1252	32	<i>Caenorhabditis elegans</i>
19976	1253	32	<i>Halothiobacillus hydrothermalis</i>
20261	1254	47	<i>Azotobacter vinelandii</i> ; <i>Streptomyces coelicolor</i> ; <i>Magnetospirillum magnetotacticum</i> ; <i>Pseudomonas aeruginosa</i> ; <i>Streptomyces atroolivaceus</i>
20370	1255	60	<i>Homo sapiens</i> ; <i>Streptomyces coelicolor</i> ; <i>Oryza sativa</i> ; <i>Zea mays</i> ; <i>Aegilops tauschii</i> ; <i>Gallus gallus</i> ; <i>Mus musculus</i> ; <i>Rhodobacter sphaeroides</i> ; <i>Rhodospirillum rubrum</i>
20399	1256	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
20400	1257	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
20401	1258	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
20402	1259	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
20403	1260	100	<i>Mycobacterium avium</i> subsp. <i>avium</i>
20404	1261	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
20405	1262	32	<i>Streptomyces coelicolor</i>
20406	1263	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
20407	1264	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
20408	1265	35	<i>Homo sapiens</i>
20409	1266	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
20410	1267	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
20411	1268	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
20412	1269	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
20413	1270	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
20414	1271	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
20415	1272	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
20416	1273	32	<i>Chloroflexus aurantiacus</i>
20417	1274	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
20418	1275	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
20419	1276	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
20420	1277	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
20421	1278	33	<i>Homo sapiens</i>
20422	1279	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
20423	1280	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
20424	1281	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
20425	1282	39	<i>Azotobacter vinelandii</i> ; <i>Coffea arabica</i>
20426	1283	33	<i>Homo sapiens</i>

20427	1284	44	<i>Agrobacterium tumefaciens</i>
20428	1285	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
20429	1286	32	<i>Mus musculus</i>
20430	1287	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
20431	1288	33	<i>Magnetospirillum magnetotacticum</i> ; <i>Xanthomonas axonopodis</i> ;
20432	1289	92	<i>Streptomyces coelicolor</i>
20433	1290	32	<i>Mycobacterium leprae</i>
20434	1291	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
20435	1292	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
20436	1293	32	<i>Serratia marcescens</i>
20958	1294	116	<i>Mycobacterium tuberculosis</i> ; <i>Mycobacterium leprae</i> ; <i>Deinococcus radiodurans</i> ; <i>Xanthomonas campestris</i>
21004	1295	44	<i>Mus musculus</i> ; <i>Streptomyces coelicolor</i>
21065	1296	39	<i>Rhodococcus opacus</i> ; <i>Oryza sativa</i>
21164	1297	44	<i>Homo sapiens</i> ; <i>Ralstonia metallidurans</i> ; <i>Desulfovibrio desulfuricans</i> ; <i>Azotobacter vinelandii</i> ; <i>Desulfitobacterium hafniense</i> ; <i>Streptomyces coelicolor</i>
21187	1298	57	<i>Mycobacterium tuberculosis</i> ; <i>Pseudomonas syringae</i> ; <i>Burkholderia fungorum</i> ; <i>Lysobacter</i> sp.
21952	1299	58	<i>Pseudomonas aeruginosa</i> ; <i>Mycobacterium tuberculosis</i> ; <i>Leishmania major</i> ; <i>Burkholderia fungorum</i> ; <i>Amycolatopsis mediterranei</i> ; <i>Streptomyces nodosus</i>
22117	1300	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
22118	1301	38	<i>Rhodospirillum rubrum</i> ; <i>Thermobifida fusca</i> ; <i>Ralstonia solanacearum</i>
22119	1302	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
22123	1303	32	<i>Thermobifida fusca</i>
22127	1304	59	<i>Mycobacterium leprae</i>
22130	1305	33	<i>Bifidobacterium longum</i>
22133	1306	38	<i>Pseudomonas putida</i> ; <i>Desulfitobacterium hafniense</i>
22134	1307	32	<i>Homo sapiens</i>
22143	1308	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
22144	1309	32	<i>Rhodospirillum rubrum</i>
22146	1310	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
22147	1311	32	<i>Pseudomonas fluorescens</i>
22154	1312	32	<i>Rhodobacter sphaeroides</i> ; <i>Bacillus stearothermophilus</i>
22222	1313	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
22236	1314	56	<i>Mycobacterium kansasii</i> ; <i>Desulfitobacterium hafniense</i> ; <i>Rhizobium meliloti</i> ; <i>Gallus gallus</i>
22301	1315	100	<i>Mycobacterium tuberculosis</i> ; <i>Azotobacter vinelandii</i>
22479	1316	77	<i>Mycobacterium avium</i> (strain 2151)
22481	1317	100	<i>Mycobacterium avium</i> (strain 2151); <i>Streptomyces coelicolor</i> ; <i>Homo sapiens</i> ; <i>Magnetospirillum magnetotacticum</i>
22482	1318	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>
22483	1319	72	<i>Mycobacterium avium</i> (strain 2151)
22616	1320	38	<i>Hordeum vulgare</i> ; <i>Amycolatopsis mediterranei</i> ; <i>Lymantria dispar</i> nuclear polyhedrosis virus; <i>Oryza sativa</i> ; <i>Bovine</i>

			<i>herpesvirus; Homo sapiens; Streptomyces hygroscopicus; Rhodospirillum rubrum; Triticum aestivum</i>
22619	1321	50	<i>Mesorhizobium loti; Ralstonia solanacearum; Thermobifida fusca; Mycobacterium tuberculosis; Caulobacter crescentus; Homo sapiens</i>
22663	1322	57	<i>Streptomyces coelicolor; Homo sapiens; Streptomyces avermitilis; Rhodobacter sphaeroides; Rhodospirillum rubrum; Desulfitobacterium hafniense; Oryza sativa</i>
22956	1323	57	<i>Burkholderia fungorum; Homo sapiens; Cavia porcellus; Azotobacter vinelandii</i>
23136	1324	100	<i>Mycobacterium tuberculosis; Mycobacterium leprae; Ralstonia solanacearum; Ralstonia metallidurans; Xylella fastidiosa; Streptomyces clavuligerus; Pseudomonas aeruginosa; Mesorhizobium loti; Myxococcus xanthus; Zea mays; Homo sapiens; Desulfovibrio desulfuricans</i>
23367	1325	41	<i>Xanthomonas axonopodis; Actinosynnema pretiosum subsp. auranticum Maytansino; Alcaligenes eutrophus; Azotobacter vinelandii; Ralstonia eutropha; Bifidobacterium longum; Pseudomonas stutzeri; Xanthomonas campestris;</i>
23368	1326	30	<i>Mycobacterium avium subsp. avium</i>
23369	1327	57	<i>Mesorhizobium loti; Magnetospirillum magnetotacticum; Mycobacterium tuberculosis; Bifidobacterium longum; Geobacter metallireducens; Klebsiella pneumoniae; Pseudomonas aeruginosa</i>
23371	1328	51	<i>Mycobacterium tuberculosis; Pseudomonas alcaligenes; Homo sapiens</i>
23372	1329	47	<i>Actinosynnema pretiosum subsp. auranticum maytansino</i>
23373	1330	33	<i>Homo sapiens; Sinorhizobium meliloti</i>
23375	1331	35	<i>Caulobacter crescentus; Ralstonia solanacearum; Deinococcus radiodurans</i>
23461	1332	90	<i>Mycobacterium leprae; Mycobacterium tuberculosis; Leishmania major</i>
23540	1333	44	<i>Ralstonia solanacearum; Leishmania major; Pseudomonas aeruginosa; Deinococcus radiodurans; Magnetospirillum magnetotacticum; Streptomyces coelicolor; Oryza sativa</i>
23733	1334	57	<i>Homo sapiens; Mycobacterium tuberculosis; Leishmania major; Mesorhizobium loti; Oryza sativa; Deinococcus radiodurans; Chlamydomonas reinhardtii</i>
23842	1335	30	<i>Mycobacterium avium subsp. avium</i>
23868	1336	32	<i>Escherichia coli</i>
23869	1337	33	<i>Bifidobacterium longum; Rattus norvegicus</i>
23870	1338	42	<i>Rhodococcus sp.; Mesorhizobium loti</i>
23908	1339	63	<i>Mycobacterium tuberculosis; Novosphingobium aromaticivorans; Caulobacter crescentus; Streptomyces coelicolor</i>
23978	1340	56	<i>Mycobacterium tuberculosis; Streptomyces coelicolor; Azotobacter vinelandii; Ralstonia solanacearum; Oryza sativa; Homo sapiens; Chloroflexus aurantiacus;</i>

			<i>Ralstonia metallidurans</i> ; <i>Burkholderia fungorum</i> ; <i>Desulfotobacterium hafniense</i> ; <i>Zea mays</i> ; <i>Mus musculus</i>
24003	1341	75	<i>Mycobacterium tuberculosis</i> ; <i>Mycobacterium leprae</i> ; <i>Giardia microti</i> ; <i>Xanthomonas axonopodis</i> ; <i>Paracoccus denitrificans</i> ; <i>Streptomyces coelicolor</i> ; <i>Caulobacter crescentus</i> ; <i>Giardia lamblia</i> ; <i>Magnetospirillum magnetotacticum</i> ; <i>Pseudomonas syringae</i> ; <i>Giardia intestinalis</i>
24155	1342	30	<i>Mycobacterium avium</i> subsp. <i>avium</i>

With respect to the organisms identified in Table 1, some of them represent multiple species, subspecies, or strains. To test whether or not particular reagents distinguish between *M. paratuberculosis* and such species, subspecies, or strains, it may be desirable to test a representative number of species, subspecies, or strains, respectively. In cases where the genetic variation is minimal within the species, subspecies, or strains, it may not be necessary to test more than one or two species, subspecies, or strains, respectively. In other cases, multiple species, subspecies, or strains may need to be tested, although initial testing can focus on the most genetically distant species, subspecies, or strains, respectively.

In another aspect, the invention provides for vectors comprising a nucleic acid of the invention. Host cells comprising such a vector are further provided by the invention.

In yet another aspect, the invention provides for isolated polypeptides encoded by the nucleic acids of the invention. For example, the nucleic acid molecule having the sequence of SEQ ID NO:1 can encode a polypeptide having an amino acid sequence of SEQ ID NO:24; the nucleic acid molecule having the sequence of SEQ ID NO:2 can encode a polypeptide having an amino acid sequence of SEQ ID NO:25; the nucleic acid molecule having the sequence of SEQ ID NO:3 can encode a polypeptide having an amino acid sequence of SEQ ID NO:26; the nucleic acid molecule having the sequence of SEQ ID NO:4 can encode a polypeptide having an amino acid sequence of SEQ ID NO:27; the nucleic acid molecule having the sequence of SEQ ID NO:5 can encode a polypeptide having an amino acid sequence of SEQ ID NO:28; the nucleic acid molecule having the sequence of SEQ ID NO:6 can encode a polypeptide having an amino acid sequence of SEQ ID NO:29; the nucleic acid molecule having the sequence of SEQ ID NO:7 can encode a polypeptide having an amino acid sequence of SEQ ID NO:30; the

nucleic acid molecule having the sequence of SEQ ID NO:8 can encode a polypeptide having an amino acid sequence of SEQ ID NO:31; the nucleic acid molecule having the sequence of SEQ ID NO:9 can encode a polypeptide having an amino acid sequence of SEQ ID NO:32; the nucleic acid molecule having the sequence of SEQ ID NO:10 can
5 encode a polypeptide having an amino acid sequence of SEQ ID NO:33; the nucleic acid molecule having the sequence of SEQ ID NO:11 can encode a polypeptide having an amino acid sequence of SEQ ID NO:34; the nucleic acid molecule having the sequence of SEQ ID NO:12 can encode a polypeptide having an amino acid sequence of SEQ ID NO:35; the nucleic acid molecule having the sequence of SEQ ID NO:13 can encode a
10 polypeptide having an amino acid sequence of SEQ ID NO:36; the nucleic acid molecule having the sequence of SEQ ID NO:14 can encode a polypeptide having an amino acid sequence of SEQ ID NO:37; the nucleic acid molecule having the sequence of SEQ ID NO:15 can encode a polypeptide having an amino acid sequence of SEQ ID NO:38; the nucleic acid molecule having the sequence of SEQ ID NO:16 can encode a polypeptide
15 having an amino acid sequence of SEQ ID NO:39; the nucleic acid molecule having the sequence of SEQ ID NO:17 can encode a polypeptide having an amino acid sequence of SEQ ID NO:40; the nucleic acid molecule having the sequence of SEQ ID NO:18 can encode a polypeptide having an amino acid sequence of SEQ ID NO:41; the nucleic acid molecule having the sequence of SEQ ID NO:19 can encode a polypeptide having an
20 amino acid sequence of SEQ ID NO:42; the nucleic acid molecule having the sequence of SEQ ID NO:20 can encode a polypeptide having an amino acid sequence of SEQ ID NO:43; the nucleic acid molecule having the sequence of SEQ ID NO:21 can encode a polypeptide having an amino acid sequence of SEQ ID NO:44; and the nucleic acid molecule having the sequence of SEQ ID NO:22 can encode a polypeptide having an
25 amino acid sequence of SEQ ID NO:45.

In another aspect, the invention provides articles of manufacture that include one or more polypeptides of the invention. In still another aspect of the invention, there are provided antibodies that have specific binding affinity for a polypeptide of the invention.

In another aspect, the invention provides for methods for detecting the presence or
30 absence of *M. paratuberculosis* in a biological sample. Such methods include contacting the biological sample with one or more of the nucleic acids of the invention (e.g., SEQ ID

NOs:1-23 and 110-1342) under standard amplification conditions, wherein an amplification product is produced if *M. paratuberculosis* nucleic acid is present in the biological sample; and detecting the presence or absence of the amplification product. Generally, the presence of the amplification product indicates the presence of *M. paratuberculosis* in the biological sample, and the absence of the amplification product indicates the absence of *M. paratuberculosis* in the biological sample. Representative animals from which the biological sample can be derived include a cow, a sheep, a goat, a rabbit, a deer, an antelope, a bison, or a human. Representative biological samples include a fecal sample and a milk sample. Further, representative nucleic acids that can be used in the above-described methods include those having the sequence of SEQ ID NO:46-101 and 1343-1354.

In another aspect, the invention provides methods for detecting the presence or absence of *M. paratuberculosis* in a biological sample. Such methods include contacting the biological sample with one or more of the nucleic acids of the invention (*e.g.*, SEQ ID NOs:1-23 and 110-1342) under hybridization conditions, wherein a hybridization complex is produced if *M. paratuberculosis* nucleic acid molecules are present in the biological sample; and detecting the presence or absence of the hybridization complex. Generally, the presence of the hybridization complex indicates the presence of *M. paratuberculosis* in the biological sample, and the absence of the hybridization complex indicates the absence of *M. paratuberculosis* in the biological sample. Typically, nucleic acids present in the biological sample are electrophoretically separated. Such electrophoretically separated nucleic acids can be attached to a solid support. Representative solid supports include nylon membranes and nitrocellulose membranes. Further, one or more nucleic acids can be labeled. Representative biological samples include a fecal sample, a milk sample, and a blood sample.

In another aspect, the invention provides methods for detecting the presence or absence of *M. paratuberculosis* in a biological sample. Such methods include contacting the biological sample with a polypeptide of the invention (*e.g.*, SEQ ID NOs:24-45), wherein a polypeptide-antibody complex is produced if an antibody having specific binding affinity for the polypeptide is present in the sample; and detecting the presence or absence of the polypeptide-antibody complex. Typically, the presence of the

polypeptide-antibody complex indicates the presence of *M. paratuberculosis* in the biological sample, and the absence of the polypeptide-antibody complex indicates the absence of *M. paratuberculosis* in the biological sample. Polypeptides used in the above-described method can be attached to a solid support. Further, representative biological samples include a blood sample and a milk sample.

In yet another aspect, the invention provides for methods for detecting the presence or absence of *M. paratuberculosis* in a biological sample. Such methods include contacting the biological sample with an antibody of the invention (*e.g.*, an antibody having specific binding affinity for a polypeptide having an amino acid sequence of SEQ ID NOs:24-45), wherein an antibody-polypeptide complex is produced if a polypeptide is present in the biological sample for which the antibody has specific binding affinity, and detecting the presence or absence of the antibody-polypeptide complex. Generally, the presence of the antibody-polypeptide complex indicates the presence of *M. paratuberculosis* in the biological sample, and the absence of the antibody-polypeptide complex indicates the absence of *M. paratuberculosis* in the biological sample. Antibodies used in the above-described methods can be bound to a solid support. Representative biological samples that can be used in the above-described methods include a blood sample and a milk sample.

In still another aspect of the invention, there are provided methods of preventing infection by *M. paratuberculosis* in an animal. Such methods include administering a compound to the animal, wherein the compound comprises a polypeptide of the invention (*e.g.*, SEQ ID NOs:24-45). Alternatively, such methods include administering a compound to the animal, wherein the compound comprises a nucleic acid of the invention (*e.g.*, a nucleic acid comprising a nucleic acid molecule having at least 75% sequence identity to SEQ ID NOs:1-23, 110-1341, or 1342). Typically, the compound immunizes the animal against *M. paratuberculosis*.

In another aspect of the invention, there is provided a composition comprising a first oligonucleotide primer and a second oligonucleotide primer, wherein the first oligonucleotide primer and the second oligonucleotide primer are each 10 to 50 nucleotides in length, and wherein the first and second oligonucleotide primers, in the presence of *M. paratuberculosis* nucleic acid, generate an amplification product under

standard amplification conditions, but do not generate an amplification product in the presence of *M. avium* subsp. *avium* nucleic acid. The invention further provides for an article of manufacture comprising such a composition.

5 In yet another aspect of the invention, there is provided an isolated nucleic acid, wherein the nucleic acid comprises a nucleic acid molecule greater than 10 nucleotides in length. Such a molecule has at least 75% sequence identity to SEQ ID NO:1355 or to the complement of SEQ ID NO:1355, and hybridizes under stringent conditions with *M. paratuberculosis* nucleic acid but does not hybridize with *M. avium* subsp. *avium* nucleic acid under the same hybridization conditions. Any of the sequences disclosed herein
10 (e.g., SEQ ID NOs:1-23, 110-1341, or 1342) can be used to design one or more oligonucleotide primers.

In still another aspect of the invention, there is provided articles of manufacture. Articles of manufacture of the invention can include one or more isolated nucleic acids of the invention.

15 In yet another aspect of the invention, the reagents and methods disclosed herein are used by a diagnostic service provider (e.g., a diagnostic testing laboratory) to obtain and report test results. For example, a provider could send out, or otherwise provide, a collection vial or other container to a customer (recipient) desiring the provider's diagnostic testing services. The container can be part of a collection kit including sterile
20 plastic ware components, for example. The collection kit further can include instructions for collecting a biological sample (e.g., feces, or milk), and for returning the container, with the sample, to the provider. Upon return to the provider, the provider can perform a diagnostic assay on the sample using the reagents and methods disclosed herein. Following completion of the assay, the provider can send or otherwise communicate
25 results of the assay to the recipient.

Unless otherwise defined, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention pertains. Although methods and materials similar or equivalent to those described herein can be used in the practice or testing of the present invention, suitable
30 methods and materials are described below. In addition, the materials, methods, and examples are illustrative only and not intended to be limiting. All publications, patent

applications, patents, and other references mentioned herein are incorporated by reference in their entirety. In case of conflict, the present specification, including definitions, will control.

5 The details of one or more embodiments of the invention are set forth in the accompanying drawings and the description below. Other features, objects, and advantages of the invention will be apparent from the drawings and detailed description, and from the claims.

DESCRIPTION OF DRAWINGS

10 Figure 1 is a sequence alignment schematic showing positions of predicted coding sequences relative to assembled contig fragments. Alignments of contig 1614 and a trimmed fragment of the 94-kb contig 1398 are shown along with each predicted coding sequence listed in Table 4. Note that the core region of genes 250 to 257 is well separated from neighboring coding regions. The integrase gene upstream of gene 250 is
15 also designated gene 249.

Figure 2 shows the sequences of *M. paratuberculosis*-specific nucleic acid molecules (SEQ ID NOs:1-23).

Figure 3 shows the polypeptide sequences (SEQ ID NOs:24-45) encoded by *M. paratuberculosis*-specific nucleic acids. An * indicates a stop codon.

20 Figure 4 shows representative nucleic acid molecules having 75%, 80%, 85%, 90%, 95%, and 99% sequence identity to SEQ ID NO:1 (SEQ ID NOs:102-107, respectively).

Figure 5 is a map of the *M. paratuberculosis* genome, showing the relative positions of novel sequences.

25 Figure 6 shows the sequences of *M. paratuberculosis*-specific nucleic acid molecules (SEQ ID NOs:110-1342).

DETAILED DESCRIPTION

30 The close genetic relationship between *M. paratuberculosis* and *M. avium* has made difficult the identification of nucleic acids and polypeptides specific to *M.*

paratuberculosis that can be used with high sensitivity and specificity to detect *M. paratuberculosis*. The present invention provides nucleic acid molecules that are unique to *M. paratuberculosis*. The invention also provides the *M. paratuberculosis*-specific polypeptides encoded by the nucleic acid molecules of the invention, and antibodies
5 having specific binding affinity for the *M. paratuberculosis*-specific polypeptides. The nucleic acid molecules, polypeptides, and antibodies of the invention can be used in methods of the invention to detect *M. paratuberculosis* in a sample. The invention additionally provides methods of preventing a *M. paratuberculosis* infection in an animal.

10 *Isolated M. paratuberculosis-specific nucleic acid molecules*

The present invention is based, in part, on the identification of nucleic acid molecules that are unique to *M. paratuberculosis*. These nucleic acid molecules are herein referred to as "*M. paratuberculosis*-specific" nucleic acid molecules. Particular nucleic acid molecules of the invention include the sequences shown in SEQ ID NOs:1-
15 23 and 110-1342. As used herein, the term "nucleic acid molecule" can include DNA molecules and RNA molecules and analogs of the DNA or RNA molecule generated using nucleotide analogs. A nucleic acid molecule of the invention can be single-stranded or double-stranded, and the strandedness will depend upon its intended use.

The invention further encompasses nucleic acid molecules that differ from the
20 nucleotide sequence of SEQ ID NOs:1-23 and 110-1342. Nucleic acid molecules of the invention include molecules that are at least 10 nucleotides in length and that have at least 75% sequence identity (*e.g.*, at least 80%, 85%, 90%, 95%, or 99% sequence identity) to any of SEQ ID NOs:1-23 and 110-1342. The full-length sizes of each of the novel *M. paratuberculosis*-specific nucleic acid molecules having the sequences shown in SEQ ID
25 NOs:1-23 are indicated in Table 2. Nucleic acid molecules that differ in sequence from the nucleic acid sequences shown in SEQ ID NOs:1-23 and 110-1342 can be generated by standard techniques, such as site-directed mutagenesis or PCR-mediated mutagenesis. In addition, nucleotide changes can be introduced randomly along all or part of the *M. paratuberculosis*-specific nucleic acid molecule, such as by saturation mutagenesis.
30 Alternatively, nucleotide changes can be introduced into a sequence by chemically synthesizing a nucleic acid molecule having such changes.

Table 2
 Sizes of *M. paratuberculosis*-specific nucleic acid molecules and polypeptides

Gene	Nucleic Acid (bp)	SEQ ID NO:	Polypeptide (amino acids)	SEQ ID NO:
10	969	1	322	24
11	576	2	191	25
38	522	3	173	26
56	582	4	193	27
57	311	5	103	28
128	576	6	191	29
135	474	7	157	30
159	558	8	185	31
217	321	9	106	32
218	2508	10	835	33
219	264	11	87	34
228	1110	12	369	35
240	672	13	223	36
241	372	14	123	37
250	600	15	199	38
251	540	16	179	39
252	291	17	96	40
253	225	18	74	41
254	441	19	146	42
255	726	20	241	43
256	426	21	141	44
257	279	22	87	45

5 In calculating percent sequence identity, two sequences are aligned and the number of identical matches of nucleotides or amino acid residues between the two sequences is determined. The number of identical matches is divided by the length of the aligned region (*i.e.*, the number of aligned nucleotides or amino acid residues) and multiplied by 100 to arrive at a percent sequence identity value. It will be appreciated that the length of the aligned region can be a portion of one or both sequences up to the full-length size of the shortest sequence. It will be appreciated that a single sequence can align differently with other sequences and hence, can have different percent sequence identity values over each aligned region. It is noted that the percent identity value is usually rounded to the nearest integer. For example, 78.1%, 78.2%, 78.3%, and 78.4% are rounded down to 78%, while 78.5%, 78.6%, 78.7%, 78.8%, and 78.9% are rounded

up to 79%. It is also noted that the length of the aligned region is always an integer.

The alignment of two or more sequences to determine percent sequence identity is performed using the algorithm described by Altschul et al. (1997, *Nucleic Acids Res.*, 25:3389-3402) as incorporated into BLAST (basic local alignment search tool) programs, available at <http://www.ncbi.nlm.nih.gov>. BLAST searches can be performed to determine percent sequence identity between a *M. paratuberculosis*-specific nucleic acid molecule of the invention and any other sequence or portion thereof aligned using the Altschul et al. algorithm. BLASTN is the program used to align and compare the identity between nucleic acid sequences, while BLASTP is the program used to align and compare the identity between amino acid sequences. When utilizing BLAST programs to calculate the percent identity between a sequence of the invention and another sequence, the default parameters of the respective programs are used. Sequence analysis of the *M. paratuberculosis*-specific nucleic acid sequences as performed herein used BLAST version 2.2.2 (updated on December 14, 2001).

The sequences of representative nucleic acids of the invention having 75%, 80%, 85%, 90%, 95%, and 99% sequence identity to SEQ ID NO:1 are shown in Figure 4 (SEQ ID NOs:102-107, respectively). Such sequences can be generated using a computer or by hand. The nucleic acid sequences shown in SEQ ID NOs:102-107 were generated by hand by randomly changing 25 nucleotides out of every 100 nucleotides of SEQ ID NO:1, 2 out of every 10, 15 out of every 100, 1 out of every 10, 5 out of every 100, or 1 nucleotide out of every 100 nucleotides of SEQ ID NO:1, respectively. By "changing," it is meant that the nucleotide at a particular position is replaced randomly with one of the other three nucleotides. It is apparent to those of ordinary skill in the art that any nucleic acid molecule within the scope of the invention can be generated using the same method described herein (*i.e.*, by similarly changing nucleotides within the sequence of SEQ ID NOs:1-23 or 110-1342).

Nucleic acid molecules of the invention between about 10 and about 30 nucleotides in length will, under standard amplification conditions, generate an amplification product in the presence of *M. paratuberculosis* nucleic acid using an appropriate second nucleic acid molecule (*e.g.*, an oligonucleotide primer that specifically anneals to *M. paratuberculosis* nucleic acid) but will not generate an amplification

product in the presence of nucleic acid from an organism other than *M. paratuberculosis* using an appropriate third nucleic acid molecule (e.g., an oligonucleotide primer that specifically anneals to nucleic acid from the other organism). As used herein, "standard amplification conditions" refer to the basic components of an amplification reaction mix, and cycling conditions that include multiple cycles of denaturing the template nucleic acid, annealing the oligonucleotide primers to the template nucleic acid, and extension of the primers by the polymerase to produce an amplification product (see, for example, U.S. Patent Nos. 4,683,195; 4,683,202; 4,800,159; and 4,965,188). The basic components of an amplification reaction mix generally include, for example, about 10-25 nmole of each of the four deoxynucleoside triphosphates, (e.g., dATP, dCTP, dTTP, and dGTP, or analogs thereof), 10-100 pmol of primers, template nucleic acid, and a polymerase enzyme. The reaction components are generally suspended in a buffered aqueous solution having a pH of between about 7 and about 9. The aqueous buffer can further include one or more co-factors (e.g., Mg^{2+} , K^{+}) required by the polymerase. Additional components such as DMSO are optional. Template nucleic acid is typically denatured at a temperature of at least about 90°C, and extension from primers is typically performed at a temperature of at least about 72°C.

The annealing temperature can be used to control the specificity of amplification. The temperature at which primers anneal to template nucleic acid must be below the T_m of each of the primers, but high enough to avoid non-specific annealing of primers to the template nucleic acid. The T_m is the temperature at which half of the DNA duplexes have separated into single strands, and can be predicted for an oligonucleotide primer using the formula provided in section 11.46 of Sambrook et al. (1989, *Molecular Cloning: A Laboratory Manual*, 2nd Ed., Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York). Non-specific amplification products are detected as bands on a gel that are not the size expected for the correct amplification product. The annealing temperature used in amplification reactions described herein to demonstrate that the claimed nucleic acid molecules are *M. paratuberculosis*-specific was 55°C and 60°C for nucleic acids isolated from bacteria or from a biological sample, respectively. It can be appreciated by those of skill in the art that appropriate positive and negative controls should be performed with every set of amplification reactions to avoid uncertainties

related to contamination and/or non-specific annealing of oligonucleotide primers and extension therefrom.

An appropriate second nucleic acid molecule is generally an oligonucleotide primer that specifically anneals to *M. paratuberculosis* nucleic acid, and that can act in combination with a nucleic acid molecule of the invention, specifically for example a 10- to 30-, or 40-, or 50-nucleotide-long nucleic acid molecule of the invention, under appropriate amplification conditions to generate an amplification product in the presence of *M. paratuberculosis* nucleic acid. In order for a second nucleic acid molecule to act in combination with a nucleic acid molecule of the invention to generate an amplification product, the two molecules must anneal to opposite strands of the template nucleic acid, and should be an appropriate distance from one another such that the polymerase can effectively polymerize across the region and such that the amplification product can be readily detected using, for example, electrophoresis. Oligonucleotide primers can be designed using, for example, a computer program such as OLIGO (Molecular Biology Insights Inc., Cascade, CO) to assist in designing primers that have similar melting temperatures. Typically, oligonucleotide primers are 10 to 30 or 40 or 50 nucleotides in length (e.g., 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, or 50 nucleotides in length), but can be longer or shorter if appropriate amplification conditions are used.

Representative pairs of oligonucleotide primers that were used to amplify each of the *M. paratuberculosis*-specific nucleic acid molecules of the invention are shown in Tables 3, 6, and 12 (SEQ ID NOs:46-101 and 1343-1354). Alternatively, the nucleic acid molecules having the sequences shown in SEQ ID NOs:1-23 and 110-1342 can be used to design a pair of oligonucleotide primers. Oligonucleotides of the invention can be obtained by restriction enzyme digestion of *M. paratuberculosis*-specific nucleic acid molecules or can be prepared by standard chemical synthesis and other known techniques.

As used herein, an organism other than *M. paratuberculosis* refers to any organism that is not *M. paratuberculosis*. Generally, only relevant organisms are used in amplification reactions to examine the specificity of a 10 or more nucleotide-long nucleic acid molecule of the invention. Particularly relevant organisms include, without

limitation, *Ralstonia solanacearum*, *Sinorhizobium meliloti*, *Homo sapiens*,
Mesorhizobium loti, *Oryza sativa*, *Drosophila melanogaster*, *Rhizobium leguminosarum*,
Xylella fastidiosa, *Deinococcus radiodurans*, *Achromobacter cycloclastes*, *Candida*
cylindracea, *Streptomyces lavendulae*, *Streptococcus pneumoniae*, *Mycobacterium*
 5 *tuberculosis*, *Pseudomonas aeruginosa*, *Sus scrofa*, *Mycobacterium leprae*, *Streptomyces*
coelicolor, *Pseudomonas* sp. (e.g., strain CA-10), *Thauera aromatica*, *Brucella*
melitensis, *Streptomyces noursei*, *Rhizobium meliloti*, *Synechococcus elongates*,
Rhodobacter capsulatus, *Agrobacterium tumefaciens*, *Mycobacterium smegmatis*,
Drosophila virilis, *Mus musculus*, *Leishmania major*, *Botrytis cinerea*, *Caulobacter*
 10 *crescentus*, *Rhodobacter sphaeroides*, *Spermatozopsis similes*, *Giardia intestinalis*,
Triticum aestivum, *Bovine herpesvirus*, *Streptomyces* sp. (e.g., strain MA-6548),
Streptomyces peucetius, *Rhizobium* sp. (e.g., strain NGR-234), *Haloferax volcanii*,
Streptomyces viridochromogenes, *Felis catus*, *Xanthomonas campestris*, *Thermotoga*
maritime, *Thermotoga neapolitana*, *Frankia alni*, *Halobacterium* NRC-1 (ATCC
 15 Accession No. 700922), *Glycine max*, *Leishmania tarentolae*, *Neisseria meningitides*,
Escherichia coli, *Caenorhabditis elegans*, *Leishmania mexicana*, *Zea mays*, *Ictalurid*
herpesvirus, *Rattus norvegicus*, *Arabidopsis thaliana*, *Pseudomonas fluorescens*, *Pantoea*
agglomerans, *Erwinia uredovora*, *Pantoea ananatis*, *Streptomyces hygroscopicus*,
Rickettsia typhi, *Pseudomonas cruciviae*, *Xanthomonas albilineans*, *Halobacterium*
 20 *salinarium*, *Micromonospora griseorubida*, *Pseudomonas paucimobilis*, *Streptomyces*
lividans, *Pyrobaculum aerophilum*, *Sinorhizobium meliloti*, *Mesorhizobium loti*, *Bacillus*
halodurans, *Trypanosoma rangeli*, *Trypanosoma minasense*, *Trypanosoma leeuwenhoekii*,
 and *Brassica napus*. A 10 or more nucleotide-long nucleic acid molecule of the invention
 in combination with an appropriate third nucleic acid molecule (e.g., a third
 25 oligonucleotide primer) will not generate an amplification product from nucleic acid of
 one or more of these other organisms.

As used herein, an "isolated" nucleic acid molecule is a nucleic acid molecule that
 is separated from other nucleic acid molecules that are usually associated with the
 isolated nucleic acid molecule. Thus, an "isolated" nucleic acid molecule includes,
 30 without limitation, a nucleic acid molecule that is free of sequences that naturally flank
 one or both ends of the nucleic acid in the genome of the organism from which the

isolated nucleic acid is derived (*e.g.*, a cDNA or genomic DNA fragment produced by PCR or restriction endonuclease digestion). Such an isolated nucleic acid molecule is generally introduced into a vector (*e.g.*, a cloning vector, or an expression vector) for convenience of manipulation or to generate a fusion nucleic acid molecule. In addition,
5 an isolated nucleic acid molecule can include an engineered nucleic acid molecule such as a recombinant or a synthetic nucleic acid molecule. A nucleic acid molecule existing among hundreds to millions of other nucleic acid molecules within, for example, a nucleic acid library (*e.g.*, a cDNA, or genomic library) or a portion of a gel (*e.g.*, agarose, or polyacrylamine) containing restriction-digested genomic DNA is not to be considered
10 an isolated nucleic acid.

Isolated nucleic acid molecules of the invention can be obtained using techniques routine in the art. For example, isolated nucleic acids within the scope of the invention can be obtained using any method including, without limitation, recombinant nucleic acid technology, and/or the polymerase chain reaction (PCR). General PCR techniques are
15 described, for example in *PCR Primer: A Laboratory Manual*, Dieffenbach & Dveksler, Eds., Cold Spring Harbor Laboratory Press, 1995. Recombinant nucleic acid techniques include, for example, restriction enzyme digestion and ligation, which can be used to isolate a nucleic acid molecule of the invention. Isolated nucleic acids of the invention also can be chemically synthesized, either as a single nucleic acid molecule or as a series
20 of oligonucleotides. In addition, isolated nucleic acid molecules of the invention also can be obtained by mutagenesis. For example, an isolated nucleic acid that shares identity with an art known *M. paratuberculosis*-specific nucleic acid sequence can be mutated using common molecular cloning techniques (*e.g.*, site-directed mutagenesis). Possible mutations include, without limitation, deletions, insertions, substitutions, and
25 combinations thereof.

Vectors containing *M. paratuberculosis*-specific nucleic acid molecules also are provided by the invention. Vectors, including expression vectors, suitable for use in the present invention are commercially available and/or produced by recombinant DNA technology methods routine in the art. A vector containing a *M. paratuberculosis*-
30 specific nucleic acid molecule can have elements necessary for expression operably linked to such a *M. paratuberculosis*-specific nucleic acid, and further can include

sequences such as those encoding a selectable marker (*e.g.*, an antibiotic resistance gene), and/or those that can be used in purification of a *M. paratuberculosis*-specific polypeptide (*e.g.*, 6xHis tag).

5 Elements necessary for expression include nucleic acid sequences that direct and regulate expression of nucleic acid coding sequences. One example of an element necessary for expression is a promoter sequence, for example, a *M. paratuberculosis*-specific promoter (*e.g.*, from the same coding sequence being expressed or from a different coding sequence) or a non-*M. paratuberculosis*-specific promoter. Elements necessary for expression also can include introns, enhancer sequences, response elements,
10 or inducible elements that modulate expression of a *M. paratuberculosis*-specific nucleic acid. Elements necessary for expression can be of bacterial, yeast, insect, mammalian, or viral origin and vectors can contain a combination of elements from different origins. Elements necessary for expression are described, for example, in Goeddel, 1990, *Gene Expression Technology: Methods in Enzymology*, 185, Academic Press, San Diego, CA.
15 As used herein, operably linked means that a promoter and/or other regulatory element(s) are positioned in a vector relative to a *M. paratuberculosis*-specific nucleic acid in such a way as to direct or regulate expression of the *M. paratuberculosis*-specific nucleic acid. Many methods for introducing nucleic acids into cells, both *in vivo* and *in vitro*, are well known to those skilled in the art and include, without limitation, calcium phosphate
20 precipitation, electroporation, heat shock, lipofection, microinjection, and viral-mediated nucleic acid transfer.

Another aspect of the invention pertains to host cells into which a vector of the invention, *e.g.*, an expression vector, or an isolated nucleic acid molecule of the invention has been introduced. The term "host cell" refers not only to the particular cell but also to
25 the progeny or potential progeny of such a cell. A host cell can be any prokaryotic or eukaryotic cell. For example, *M. paratuberculosis*-specific nucleic acids can be expressed in bacterial cells such as *E. coli*, or in insect cells, yeast or mammalian cells (such as Chinese hamster ovary cells (CHO) or COS cells). Other suitable host cells are known to those skilled in the art.

30 Vectors containing representative nucleic acid molecules unique to *M. paratuberculosis* were deposited with the American Type Culture Collection (ATCC),

10801 University Boulevard Manassas, VA 20110, on April 3, 2002, and assigned
Accession Numbers PTA-4199, and PTA-4200. Each deposit will be maintained under
the terms of the Budapest Treaty on the International Recognition of the Deposit of
Microorganisms for the Purposes of Patent Procedure. This deposit was made merely as a
5 convenience for those of skill in the art and is not an admission that a deposit is required
under 35 U.S.C. §112.

Purified M. paratuberculosis polypeptides

One aspect of the invention pertains to purified *M. paratuberculosis*-specific
10 polypeptides, as well as polypeptide fragments. A "*M. paratuberculosis*-specific
polypeptide" refers to a polypeptide encoded by a nucleic acid molecule that is unique to
M. paratuberculosis (e.g., *M. paratuberculosis*-specific nucleic acid molecules, for
example, those having the sequence shown in SEQ ID NOs:1-23 and 110-1342).
Predicted amino acid sequences encoded by novel *M. paratuberculosis*-specific nucleic
15 acids of the invention are shown in SEQ ID NOs:24-45.

The term "purified" polypeptide as used herein refers to a polypeptide that has
been separated or purified from cellular components that naturally accompany it.
Typically, the polypeptide is considered "purified" when it is at least 70% (e.g., at least
75%, 80%, 85%, 90%, 95%, or 99%) by dry weight, free from the proteins and naturally
20 occurring molecules with which it is naturally associated. Since a polypeptide that is
chemically synthesized is, by nature, separated from the components that naturally
accompany it, a synthetic polypeptide is "purified."

M. paratuberculosis-specific polypeptides can be purified from natural sources
(e.g., a biological sample) by known methods such as DEAE ion exchange, gel filtration,
25 and hydroxyapatite chromatography. A purified *M. paratuberculosis*-specific
polypeptide also can be obtained by expressing a *M. paratuberculosis*-specific nucleic
acid in an expression vector, for example. In addition, a purified *M. paratuberculosis*-
specific polypeptide can be obtained by chemical synthesis. The extent of purity of a *M.*
paratuberculosis-specific polypeptide can be measured using any appropriate method,
30 e.g., column chromatography, polyacrylamide gel electrophoresis, or HPLC analysis.

In addition to naturally-occurring *M. paratuberculosis*-specific polypeptides, the skilled artisan will further appreciate that changes can be introduced into a nucleic acid molecule (*e.g.*, those having the sequence shown in SEQ ID NOs:1-23, 110-1341, or 1342) as discussed herein, thereby leading to changes in the amino acid sequence of the encoded polypeptide. For example, changes can be introduced into *M. paratuberculosis*-specific nucleic acid coding sequences leading to conservative and/or non-conservative amino acid substitutions at one or more amino acid residues. A "conservative amino acid substitution" is one in which one amino acid residue is replaced with a different amino acid residue having a similar side chain. Similarity between amino acid residues has been assessed in the art. For example, Dayhoff et al. (1978, in *Atlas of Protein Sequence and Structure*, Vol. 5, Suppl. 3, pp 345-352) provides frequency tables for amino acid substitutions that can be employed as a measure of amino acid similarity. A non-conservative substitution is one in which an amino acid residue is replaced with an amino acid residue that does not have a similar side chain.

The invention also provides for chimeric or fusion polypeptides. As used herein, a "chimeric" or "fusion" polypeptide includes a *M. paratuberculosis*-specific polypeptide operatively linked to a heterologous polypeptide. A heterologous polypeptide can be at either the N-terminus or C-terminus of the *M. paratuberculosis*-specific polypeptide. Within a chimeric or fusion polypeptide, the term "operatively linked" is intended to indicate that the two polypeptides are encoded in-frame relative to one another. In a fusion polypeptide, the heterologous polypeptide generally has a desired property such as the ability to purify the fusion polypeptide (*e.g.*, by affinity purification). A chimeric or fusion polypeptide of the invention can be produced by standard recombinant DNA techniques, and can use commercially available vectors.

A polypeptide commonly used in a fusion polypeptide for purification is glutathione S-transferase (GST), although numerous other polypeptides are available and can be used. In addition, a proteolytic cleavage site can be introduced at the junction between a *M. paratuberculosis*-specific polypeptide and a non-*M. paratuberculosis*-specific polypeptide to enable separation of the two polypeptides subsequent to purification of the fusion polypeptide. Enzymes that cleave such proteolytic sites include Factor Xa, thrombin, or enterokinase. Representative expression vectors encoding a

heterologous polypeptide that can be used in affinity purification of a *M. paratuberculosis* polypeptide include pGEX (Pharmacia Biotech Inc; Smith & Johnson, 1988, *Gene*, 67:31-40), pMAL (New England Biolabs, Beverly, MA) and pRIT5 (Pharmacia, Piscataway, NJ).

5

Anti-M. paratuberculosis-specific antibodies

Another aspect of the invention relates to anti-*M. paratuberculosis*-specific antibodies. The term "anti-*M. paratuberculosis*-specific antibodies" as used herein refers to immunoglobulin molecules and immunologically active portions of immunoglobulin molecules that have specific binding affinity for a *M. paratuberculosis*-specific polypeptide. The invention provides polyclonal and monoclonal antibodies that have specific binding affinity for *M. paratuberculosis*-specific polypeptides. The sequences of numerous *M. paratuberculosis*-specific polypeptides that can be used to generate anti-*M. paratuberculosis*-specific antibodies are disclosed herein (*e.g.*, SEQ ID NOs:24-45).

15 Examples of immunologically active portions of immunoglobulin molecules include F(ab) and F(ab')₂ fragments, which can be generated by treating an immunoglobulin molecule with an enzyme such as pepsin. As used herein, an antibody that has "specific binding affinity" for a *M. paratuberculosis*-specific polypeptide is an antibody that binds a *M. paratuberculosis*-specific polypeptide but does not bind a non-*M. paratuberculosis*-specific polypeptides. A non-*M. paratuberculosis*-specific polypeptide as used herein refers to a polypeptide that may or may not be found in *M. paratuberculosis*, but is found in at least one other organism besides *M. paratuberculosis*.

20

A purified *M. paratuberculosis*-specific polypeptide or a fragment thereof can be used as an immunogen to generate polyclonal or monoclonal antibodies that have specific binding affinity for *M. paratuberculosis*-specific polypeptides. Such antibodies can be generated using standard techniques as described herein. Full-length *M. paratuberculosis*-specific polypeptides (see Table 2) or, alternatively, antigenic fragments of *M. paratuberculosis*-specific polypeptides can be used as immunogens. An antigenic fragment of a *M. paratuberculosis*-specific polypeptide usually includes at least 8 (*e.g.*, 10, 15, 20, or 30) amino acid residues of a *M. paratuberculosis*-specific polypeptide (*e.g.*, having the sequence shown in SEQ ID NOs:23-45), and encompasses an epitope of a *M.*

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30

paratuberculosis-specific polypeptide such that an antibody (*e.g.*, polyclonal or monoclonal) raised against the antigenic fragment has specific binding affinity for a *M. paratuberculosis*-specific polypeptide.

Antibodies are typically prepared by first immunizing a suitable animal (*e.g.*, a rabbit, a goat, a mouse or another mammal) with an immunogenic preparation. An appropriate immunogenic preparation can contain, for example, a recombinantly expressed or chemically synthesized *M. paratuberculosis*-specific polypeptide, of a fragment thereof. The preparation can further include an adjuvant, such as Freund's complete or incomplete adjuvant, or similar immunostimulatory agent. Immunization of a suitable animal with an immunogenic *M. paratuberculosis*-specific polypeptide preparation induces a polyclonal anti-*M. paratuberculosis*-specific antibody response.

The titer of the anti-*M. paratuberculosis*-specific antibody in the immunized animal can be monitored over time by standard techniques, such as with an enzyme-linked immunosorbent assay (ELISA) using immobilized *M. paratuberculosis*-specific polypeptides. If desired, the antibody molecules directed against *M. paratuberculosis*-specific polypeptides can be isolated from the animal (*e.g.*, from the blood) and further purified by well-known techniques such as protein A chromatography to obtain the IgG fraction.

At an appropriate time after immunization, *e.g.*, when the anti-*M. paratuberculosis*-specific antibody titers are highest, antibody-producing cells can be obtained from the animal and used to prepare monoclonal antibodies by standard techniques, such as the hybridoma technique originally described by Kohler & Milstein (1975, *Nature*, 256:495-497), the human B cell hybridoma technique (Kozbor et al., 1983, *Immunol. Today*, 4:72), or the EBV-hybridoma technique (Cole et al., 1985, *Monoclonal Antibodies and Cancer Therapy*, Alan R. Liss, Inc., pp. 77-96). The technology for producing various monoclonal antibody hybridomas is well known (see, generally, *Current Protocols in Immunology*, 1994, Coligan et al. (Eds.), John Wiley & Sons, Inc., New York, NY). Briefly, an immortal cell line (*e.g.*, a myeloma cell line) is fused to lymphocytes (*e.g.*, splenocytes) from an animal immunized with an immunogenic *M. paratuberculosis*-specific polypeptide as described above, and the culture supernatants of the resulting hybridoma cells are screened to identify a hybridoma producing a

monoclonal antibody that has specific binding affinity for the *M. paratuberculosis*-specific polypeptide.

Any of the well-known protocols used for fusing lymphocytes and immortalized cell lines can be applied for the purpose of generating an anti-*M. paratuberculosis*-specific monoclonal antibody (see, e.g., *Current Protocols in Immunology*, supra; Galfre et al., 1977, *Nature*, 266:55052; R.H. Kenneth, in *Monoclonal Antibodies: A New Dimension In Biological Analyses*, Plenum Publishing Corp., New York, New York, 1980; and Lerner, 1981, *Yale J. Biol. Med.*, 54:387-402). Moreover, the ordinary skilled worker will appreciate that there are many variations of such methods that also would be useful. Typically, the immortal cell line is derived from the same species as the lymphocytes. For example, murine hybridomas can be made by fusing lymphocytes from a mouse immunized with an immunogenic preparation with an immortalized mouse cell line, e.g., a myeloma cell line that is sensitive to culture medium containing hypoxanthine, aminopterin and thymidine ("HAT medium"). Any of a number of ATCC-
15 available myeloma cell lines can be used as a fusion partner according to standard techniques, e.g., the P3-NS1/1-Ag4-1, P3-x63-Ag8.653 or Sp2/O-Ag14 myeloma lines. Typically, HAT-sensitive mouse myeloma cells are fused to mouse splenocytes using polyethylene glycol (PEG). Hybridoma cells resulting from the fusion are then selected using HAT medium. Hybridoma cells producing a monoclonal antibody are detected by
20 screening the hybridoma culture supernatants for antibodies that bind *M. paratuberculosis*-specific polypeptides, e.g., using a standard ELISA assay.

As an alternative to preparing monoclonal antibody-secreting hybridomas, an anti-*M. paratuberculosis*-specific monoclonal antibody can be identified and isolated by screening a recombinant combinatorial immunoglobulin library (e.g., an antibody phage display library) with *M. paratuberculosis*-specific polypeptides. Immunoglobulin library members that have specific binding affinity for *M. paratuberculosis*-specific polypeptides can be isolated from such libraries. Kits for generating and screening phage display libraries are commercially available (e.g., the Pharmacia Recombinant Phage Antibody System, Catalog No. 27-9400-01; and the Stratagene SurfZAP Phage Display Kit,
25 Catalog No. 240612). Additionally, examples of methods and reagents particularly amenable for use in generating and screening antibody display libraries can be found in,

for example, U.S. Patent No. 5,223,409; PCT Publication No. WO 92/20791; PCT Publication No. WO 93/01288; Hay et al., 1992, *Hum. Antibod. Hybridomas*, 3:81-85; Griffiths et al., 1993, *EMBO J.*, 12:725-734; and references therein.

5 Additionally, recombinant anti-*M. paratuberculosis*-specific antibodies, such as chimeric and humanized monoclonal antibodies, comprising both human and non-human portions, are within the scope of the invention. Such chimeric and humanized monoclonal antibodies can be produced by recombinant DNA techniques known in the art, for example using methods described in PCT Publication No. WO 87/02671; European Patent (EP) Application 184,187; U.S. Patent No. 4,816,567; Better et al., 1988, 10 *Science*, 240:1041-1043; Shaw et al., 1988, *J. Natl. Cancer Inst.*, 80:1553-1559); U.S. Patent 5,225,539; Verhoeyan et al., 1988, *Science*, 239:1534; Beidler et al., 1988, *J. Immunol.*, 141:4053-4060; and references therein.

An anti-*M. paratuberculosis*-specific antibody (e.g., a monoclonal antibody) can be used to isolate *M. paratuberculosis*-specific polypeptides by standard techniques, such 15 as affinity chromatography or immunoprecipitation. An anti-*M. paratuberculosis*-specific antibody can facilitate the purification of natural *M. paratuberculosis*-specific polypeptides from cells and of recombinantly-produced *M. paratuberculosis*-specific polypeptides expressed in host cells. Moreover, an anti-*M. paratuberculosis*-specific antibody can be used to detect *M. paratuberculosis*-specific polypeptides (e.g., in a 20 cellular lysate or cell supernatant) in order to evaluate the presence or absence of the *M. paratuberculosis*-specific polypeptides. Anti-*M. paratuberculosis*-specific antibodies can be used diagnostically to detect *M. paratuberculosis*-specific polypeptides, and hence, *M. paratuberculosis*, in a biological sample, e.g., to determine the infection status of an animal, or to determine the efficacy of a given treatment regimen.

25

Methods of detecting M. paratuberculosis

The *M. paratuberculosis*-specific nucleic acid molecules and polypeptides, and the anti-*M. paratuberculosis*-specific antibodies described herein can be used in diagnostic assays for the detection of *M. paratuberculosis*. Diagnostic assays for 30 determining the presence or absence of *M. paratuberculosis* are performed using a biological sample (e.g., fecal, blood, milk) to determine whether an animal has been

exposed to or is infected with *M. paratuberculosis*. An exemplary method for detecting the presence or absence of *M. paratuberculosis* in a biological sample involves obtaining a biological sample from an animal and contacting the biological sample with an appropriate agent capable of detecting *M. paratuberculosis*-specific nucleic acids or polypeptides, or anti-*M. paratuberculosis*-specific antibodies.

The term "biological sample" is intended to include cells and biological fluids obtained from an animal. In one embodiment, a biological sample contains polypeptides from the animal. Alternatively, the biological sample can contain nucleic acid molecules from the animal, or the biological sample can contain antibodies from the animal. It should be understood that any biological sample in which *M. paratuberculosis*-specific nucleic acids or polypeptides, or anti-*M. paratuberculosis*-specific antibodies may be present can be utilized in the methods described herein.

In one embodiment, an agent for detecting the presence or absence of *M. paratuberculosis* in a biological sample is an isolated *M. paratuberculosis*-specific nucleic acid molecule of the invention. The presence of *M. paratuberculosis*-specific nucleic acids in a sample indicates the presence of *M. paratuberculosis* in the sample. Methods for detecting nucleic acids include, for example, PCR and nucleic acid hybridizations (e.g., Southern blot, Northern blot, or *in situ* hybridizations). Specifically, an agent can be one or more oligonucleotides (e.g., oligonucleotide primers) capable of amplifying *M. paratuberculosis*-specific nucleic acids using PCR. PCR methods generally include the steps of collecting a biological sample from an animal, isolating nucleic acid (e.g., DNA, RNA, or both) from the sample, and contacting the nucleic acid with one or more oligonucleotide primers that hybridize(s) with specificity to *M. paratuberculosis*-specific nucleic acid under conditions such that amplification of the *M. paratuberculosis*-specific nucleic acid occurs if *M. paratuberculosis* is present. In the presence of *M. paratuberculosis*, an amplification product corresponding to the *M. paratuberculosis*-specific nucleic acid is produced. Conditions for amplification of a nucleic acid and detection of an amplification product are known to those of skill in the art (see, e.g., *PCR Primer: A Laboratory Manual*, 1995, Dieffenbach & Dveksler, Eds., Cold Spring Harbor Laboratory Press, Cold Spring Harbor, NY; and U.S. Patent Nos. 4,683,195; 4,683,202; 4,800,159; and 4,965,188). Modifications to the original PCR also

have been developed. For example, anchor PCR, RACE PCR, or ligation chain reaction (LCR) are additional PCR methods known in the art (see, e.g., Landegran et al., 1988, *Science*, 241:1077-1080; and Nakazawa et al., 1994, *Proc. Natl. Acad. Sci. USA*, 91:360-364).

5 Alternatively, an agent for detecting *M. paratuberculosis*-specific nucleic acids can be a labeled oligonucleotide probe capable of hybridizing to *M. paratuberculosis*-specific nucleic acids on a Southern blot. An oligonucleotide probe can be, for example, a *M. paratuberculosis*-specific nucleic acid molecule such as a nucleic acid molecule having the sequence shown in SEQ ID NO:1-22, 110-1341, or 1342, or a fragment
10 thereof. In the presence of *M. paratuberculosis*, a hybridization complex is produced between *M. paratuberculosis* nucleic acid and the oligonucleotide probe. Hybridization between nucleic acid molecules is discussed in detail in Sambrook et al. (1989, *Molecular Cloning: A Laboratory Manual*, 2nd Ed., Cold Spring Harbor Laboratory Press, Cold Spring Harbor, NY; Sections 7.37-7.57, 9.47-9.57, 11.7-11.8, and 11.45-11.57).

15 For oligonucleotide probes less than about 100 nucleotides, Sambrook et al. discloses suitable Southern blot conditions in Sections 11.45-11.46. The T_m between a sequence that is less than 100 nucleotides in length and a second sequence can be calculated using the formula provided in Section 11.46. Sambrook et al. additionally discloses prehybridization and hybridization conditions for a Southern blot that uses
20 oligonucleotide probes greater than about 100 nucleotides (see Sections 9.47-9.52). Hybridizations with an oligonucleotide greater than 100 nucleotides generally are performed 15-25°C below the T_m . The T_m between a sequence greater than 100 nucleotides in length and a second sequence can be calculated using the formula provided in Sections 9.50-9.51 of Sambrook et al. Additionally, Sambrook et al. recommends the
25 conditions indicated in Section 9.54 for washing a Southern blot that has been probed with an oligonucleotide greater than about 100 nucleotides.

 The conditions under which membranes containing nucleic acids are prehybridized and hybridized, as well as the conditions under which membranes containing nucleic acids are washed to remove excess and non-specifically bound probe
30 can play a significant role in the stringency of the hybridization. Such hybridizations can be performed, where appropriate, under moderate or high stringency conditions. Such

conditions are described, for example, in Sambrook et al. section 11.45-11.46. For example, washing conditions can be made more stringent by decreasing the salt concentration in the wash solutions and/or by increasing the temperature at which the washes are performed. In addition, interpreting the amount of hybridization can be affected, for example, by the specific activity of the labeled oligonucleotide probe, by the number of probe-binding sites on the template nucleic acid to which the probe has hybridized, and by the amount of exposure of an autoradiograph or other detection medium.

It will be readily appreciated by those of ordinary skill in the art that although any number of hybridization and washing conditions can be used to examine hybridization of a probe nucleic acid molecule to immobilized target nucleic acids, it is more important to examine hybridization of a probe to target nucleic acids, for example, from *M. paratuberculosis* and at least one organism other than *M. paratuberculosis*, under identical hybridization, washing, and exposure conditions. Preferably, the target nucleic acids (e.g., nucleic acids from *M. paratuberculosis* and at least one organism other than *M. paratuberculosis*) are on the same membrane. Representative Southern blot conditions are described in Example 3.

A nucleic acid molecule is deemed to hybridize to *M. paratuberculosis* nucleic acids but not to nucleic acids from an organism other than *M. paratuberculosis* if hybridization to nucleic acid from *M. paratuberculosis* is at least 5-fold (e.g., at least 6-fold, 7-fold, 8-fold, 9-fold, 10-fold, 20-fold, 50-fold, or 100-fold) greater than hybridization to nucleic acid from an organism other than *M. paratuberculosis*. The amount of hybridization can be quantitated directly on a membrane or from an autoradiograph using, for example, a PhosphorImager or a Densitometer (Molecular Dynamics, Sunnyvale, CA). It can be appreciated that useful primers and probes of the invention include primers and probes that anneal and hybridize, respectively, to nucleic acids of organisms other than *M. paratuberculosis* provided that such nucleic acids are not typically present in the relevant test animals. For example, the fact that a particular primer or probe anneals or hybridizes, respectively, to human nucleic acid does not diminish the value of that primer or probe for detecting the presence or absence of *M.*

paratuberculosis in ruminants, since ruminants typically are not contaminated with human nucleic acid.

In addition, anti-*M. paratuberculosis*-specific antibodies provided by the invention can be used as agents to detect the presence or absence of *M. paratuberculosis*-specific polypeptides in a biological sample. The presence of *M. paratuberculosis*-specific polypeptides is an indication of the presence of *M. paratuberculosis* in the sample. Techniques for detecting *M. paratuberculosis*-specific polypeptides include enzyme linked immunosorbent assays (ELISAs), Western blots, immunoprecipitations and immunofluorescence. An antibody of the invention can be polyclonal or monoclonal, and usually is detectably labeled. An antibody having specific binding affinity for a *M. paratuberculosis*-specific polypeptide can be generated using methods described herein. The antibody can be attached to a solid support such as a microtiter plate using methods known in the art (see, for example, Leahy et al., 1992, *BioTechniques*, 13:738-743). In the presence of *M. paratuberculosis*, an antibody-polypeptide complex is formed.

In addition, *M. paratuberculosis*-specific polypeptides of the invention can be used as an agent to detect the presence or absence of anti-*M. paratuberculosis*-specific antibodies in a biological sample. The presence of anti-*M. paratuberculosis*-specific antibodies in a sample indicates that the animal from which the sample was obtained mounted an immune response toward *M. paratuberculosis*. Given the etiology of *M. paratuberculosis* in its host animals, an animal that has detectable levels of anti-*M. paratuberculosis*-specific antibodies is likely infected with *M. paratuberculosis*. Alternatively, an animal that is positive for anti-*M. paratuberculosis*-specific antibodies may have resisted infection following a previous exposure to *M. paratuberculosis*, or may possess maternally-transmitted anti-*M. paratuberculosis*-specific antibodies. Techniques for detecting anti-*M. paratuberculosis*-specific antibodies in a biological sample include ELISAs, Western blots, immunoprecipitations, and immunofluorescence. A *M. paratuberculosis*-specific polypeptide can be attached to a solid support such as a microtiter plate by known methods (Leahy et al., *supra*). In the presence of *M. paratuberculosis*, a polypeptide-antibody complex is formed.

Detection of an amplification product, a hybridization complex, an antibody-polypeptide complex, or a polypeptide-antibody complex is usually accomplished by

detectably labeling the respective agent. The term "labeled" with regard to an agent (*e.g.*, an oligonucleotide, a polypeptide, or an antibody) is intended to encompass direct labeling of the agent by coupling (*i.e.*, physically linking) a detectable substance to the agent, as well as indirect labeling of the agent by reactivity with another reagent that is directly labeled with a detectable substance. Detectable substances include various enzymes, prosthetic groups, fluorescent materials, luminescent materials, bioluminescent materials, and radioactive materials. Examples of suitable enzymes include horseradish peroxidase, alkaline phosphatase, β -galactosidase, or acetylcholinesterase; examples of suitable prosthetic group complexes include streptavidin/biotin and avidin/biotin; examples of suitable fluorescent materials include umbelliferone, fluorescein, fluorescein isothiocyanate, rhodamine, dichlorotriazinylamine fluorescein, dansyl chloride or phycoerythrin; an example of a luminescent material includes luminol; examples of bioluminescent materials include luciferase, luciferin, and aequorin, and examples of suitable radioactive material include ^{125}I , ^{131}I , ^{35}S or ^3H . Examples of indirect labeling include using a fluorescently labeled secondary antibody to detect an appropriate agent (*e.g.*, a primary antibody), or end-labeling an agent with biotin such that it can be detected with fluorescently labeled streptavidin.

In another embodiment, the methods further involve obtaining a biological sample from an animal known to be infected with *M. paratuberculosis* (positive control) and a non-infected (negative control) animal, contacting the control samples with an agent capable of detecting *M. paratuberculosis*-specific nucleic acids or polypeptides, or anti-*M. paratuberculosis*-specific antibodies, such that the presence or absence of *M. paratuberculosis*-specific nucleic acids or polypeptides, or anti-*M. paratuberculosis*-specific antibodies in the samples is determined. The presence or absence of *M. paratuberculosis*-specific nucleic acids or polypeptides, or anti-*M. paratuberculosis*-specific antibodies in the control samples should correlate with the presence and absence of *M. paratuberculosis* in the positive and negative control samples, respectively.

Methods of preventing a M. paratuberculosis infection

In one aspect, the invention provides methods for preventing a disease or condition associated with infection by *M. paratuberculosis* (*e.g.*, Johne's disease) in an animal by administering a compound to the animal that immunizes the animal against *M.*

paratuberculosis infection. Animals at risk for *M. paratuberculosis* infection can be administered the compound prior to the manifestation of symptoms that are characteristic of a *M. paratuberculosis* infection, such that a *M. paratuberculosis* infection is prevented or delayed in its progression.

5 In one embodiment, a compound that immunizes an animal can be a *M. paratuberculosis*-specific polypeptide. The sequences of representative *M. paratuberculosis*-specific polypeptides are disclosed herein (e.g., SEQ ID NOs:24-45) and can be produced using methods described herein. An *M. paratuberculosis*-specific polypeptide can be a fusion polypeptide, for example a *M. paratuberculosis*-specific
10 polypeptide-immunoglobulin fusion polypeptide in which all or part of a *M. paratuberculosis*-specific polypeptide is fused to sequences derived from a member of the immunoglobulin family. An *M. paratuberculosis*-specific polypeptide or fusion polypeptide of the invention can be used as an immunogen to elicit anti-*M. paratuberculosis*-specific antibodies in an animal, thereby immunizing the animal.

15 In another embodiment, a compound that immunizes an animal can be a *M. paratuberculosis*-specific nucleic acid molecule. A *M. paratuberculosis*-specific nucleic acid molecule used to immunize an animal can include one of the *M. paratuberculosis*-specific nucleic acid molecules having the sequence shown in SEQ ID NOs:1-23, 110-1341, or 1342. *M. paratuberculosis*-specific nucleic acid coding sequences (e.g., full-
20 length or otherwise) can be introduced into an appropriate expression vector such that a *M. paratuberculosis*-specific polypeptide or fusion polypeptide is produced in the animal upon appropriate expression of the expression vector. Expression of the *M. paratuberculosis*-specific nucleic acid molecule and production of a *M. paratuberculosis*-specific polypeptide in an animal thereby elicits an immune response in the animal and
25 thereby immunizes the animal.

 Compounds that can be used in immunogenic compositions of the invention (e.g., *M. paratuberculosis*-specific nucleic acid molecules or *M. paratuberculosis*-specific polypeptides) can be incorporated into pharmaceutical compositions suitable for administration. Such compositions typically comprise the nucleic acid molecule or
30 polypeptide, and a pharmaceutically acceptable carrier. As used herein, "pharmaceutically acceptable carrier" is intended to include any and all solvents,

dispersion media, coatings, antibacterial and anti-fungal agents, isotonic and absorption delaying agents, and the like, compatible with pharmaceutical administration. The use of such media and agents for pharmaceutically active substances is well known in the art. Except insofar as any conventional media or agent is incompatible with the active
5 compound, use thereof in the compositions is contemplated. Supplementary active compounds can also be incorporated into the compositions.

A pharmaceutical composition of the invention is formulated to be compatible with its intended route of administration. Examples of routes of administration include parenteral, *e.g.*, intravenous, intradermal, subcutaneous, oral (*e.g.*, ingestion or
10 inhalation), transdermal (topical), transmucosal, and rectal administration. Solutions or suspensions used for parenteral, intradermal, or subcutaneous application can include the following components: a sterile diluent such as water for injection, saline solution (*e.g.*, phosphate buffered saline (PBS)), fixed oils, a polyol (for example, glycerol, propylene glycol, and liquid polyethylene glycol, and the like), glycerine, or other synthetic
15 solvents; antibacterial and antifungal agents such as parabens, chlorobutanol, phenol, ascorbic acid, thimerosal, and the like; antioxidants such as ascorbic acid or sodium bisulfite; chelating agents such as ethylenediaminetetraacetic acid; buffers such as acetates, citrates or phosphates and agents for the adjustment of tonicity such as sodium chloride or dextrose. The proper fluidity can be maintained, for example, by the use of a
20 coating such as lecithin, by the maintenance of the required particle size in the case of dispersion and by the use of surfactants. In many cases, it will be preferable to include isotonic agents, for example, sugars, polyalcohols such as mannitol or sorbitol, and sodium chloride in the composition. Prolonged administration of the injectable compositions can be brought about by including an agent that delays absorption. Such
25 agents include, for example, aluminum monostearate and gelatin. The parenteral preparation can be enclosed in ampoules, disposable syringes or multiple dose vials made of glass or plastic.

Oral compositions generally include an inert diluent or an edible carrier. Oral compositions can be liquid, or can be enclosed in gelatin capsules or compressed into
30 tablets. Pharmaceutically compatible binding agents, and/or adjuvant materials can be included as part of an oral composition. Tablets, pills, capsules, troches and the like can

contain any of the following ingredients, or compounds of a similar nature: a binder such as microcrystalline cellulose, gum tragacanth or gelatin; an excipient such as starch or lactose; a disintegrating agent such as alginic acid, Primogel, or corn starch; a lubricant such as magnesium stearate or Sterotes; a glidant such as colloidal silicon dioxide; a
5 sweetening agent such as sucrose or saccharin; or a flavoring agent such as peppermint, methyl salicylate, or orange flavoring. Transmucosal administration can be accomplished through the use of nasal sprays or suppositories. For transdermal administration, the active compounds are formulated into ointments, salves, gels, or creams as generally known in the art.

10 It is especially advantageous to formulate oral or parenteral compositions in dosage unit form for ease of administration and uniformity of dosage. Dosage unit form as used herein refers to physically discrete units suited as unitary dosages for an animal to be treated; each unit containing a predetermined quantity of active compound calculated to produce the desired therapeutic effect in association with the required pharmaceutical
15 carrier. The dosage unit forms of the invention are dependent upon the amount of a compound necessary to immunize the animal. The amount of a compound necessary to immunize an animal can be formulated in a single dose, or can be formulated in multiple dosage units. Immunization of an animal may require a one-time dose, or may require repeated doses.

20 For polypeptide vaccines, the dose typically is from about 0.1 mg/kg to about 100 mg/kg of body weight (generally, about 0.5 mg/kg to about 5 mg/kg). Modifications such as lipidation (*Cruikshank et al., 1997, J. Acquired Immune Deficiency Syndromes and Human Retrovirology*, 14:193) can be used to stabilize polypeptides and to enhance uptake and tissue penetration. For nucleic acid vaccines, the dose administered will
25 depend on the level of expression of the expression vector. Preferably, the amount of vector that produces an amount of a *M. paratuberculosis*-specific polypeptide from about 0.1 mg/kg to about 100 mg/kg of body weight is administered to an animal.

Articles of manufacture

30 The invention encompasses articles of manufacture (e.g., kits) for detecting the presence of *M. paratuberculosis*-specific nucleic acids or polypeptides, or anti-*M.*

paratuberculosis-specific antibodies in a biological sample (a test sample). Such kits can be used to determine if an animal has been exposed to, or is infected with, *M.*

paratuberculosis. For example, a kit of the invention can include an agent capable of detecting *M. paratuberculosis*-specific nucleic acids or polypeptides, or anti-*M.*

- 5 *paratuberculosis*-specific antibodies in a biological sample (e.g., a *M. paratuberculosis*-specific oligonucleotide, an anti-*M. paratuberculosis*-specific antibody, or a *M. paratuberculosis*-specific polypeptide, respectively).

For antibody-based kits to detect *M. paratuberculosis*-specific polypeptides, the kit can include, for example, a first antibody (e.g., attached to a solid support) that has
10 specific binding affinity for a *M. paratuberculosis*-specific polypeptide and, optionally, a second antibody which binds to *M. paratuberculosis*-specific polypeptides or to the first antibody and is detectably labeled. For oligonucleotide-based kits to detect *M. paratuberculosis*-specific nucleic acids, the kit may comprise, for example, one or more oligonucleotides. For example, a kit of the invention can include a detectably labeled
15 oligonucleotide probe that hybridizes to a *M. paratuberculosis*-specific nucleic acid molecule or a pair of oligonucleotide primers for amplifying a *M. paratuberculosis*-specific nucleic acid molecule. Such oligonucleotides provided in a kit of the invention can be detectably labeled or, alternatively, the components necessary for detectably labeling an oligonucleotide can be provided in the kit. Polypeptide-based kits for
20 detecting anti-*M. paratuberculosis*-specific antibodies in a biological sample can contain a *M. paratuberculosis*-specific polypeptide as disclosed herein (e.g., attached to a solid support) and, optionally, an antibody which binds to *M. paratuberculosis*-specific polypeptides or to an anti-*M. paratuberculosis*-specific antibody and is detectably labeled.

- 25 Kits can include additional reagents (e.g., buffers, co-factors, or enzymes) as well as reagents for detecting the agent (e.g., labels or other detection molecules), as well as instructions for using such agents and reagents to detect the presence or absence of *M. paratuberculosis*-specific nucleic acids or polypeptides, or anti-*M. paratuberculosis*-specific antibodies. The kit can also contain a control sample or a series of control
30 samples that can be assayed and compared to the biological sample. Each component of

the kit is usually enclosed within an individual container and all of the various containers are within a single package.

The invention also encompasses articles of manufacture (e.g., vaccines) for preventing *M. paratuberculosis* infection in an animal. Articles of manufacture of the invention can include pharmaceutical compositions containing either a *M. paratuberculosis*-specific nucleic acid molecule or a *M. paratuberculosis*-specific polypeptide. Such nucleic acid molecules or polypeptides are formulated for administration as described herein, and are packaged appropriately for the intended route of administration. Pharmaceutical compositions of the invention further can include instructions for administration.

The invention will be further described in the following examples, which do not limit the scope of the invention described in the claims.

EXAMPLES

Example 1 - Mycobacterial strains

Mycobacteria used in this study are listed in Table 3. All mycobacteria were cultured in Middlebrook 7H9 media with 0.05% Tween 80 and oleic acid albumin dextrose complex (Becton Dickinson Microbiology, Sparks, MD). Cultures containing *M. paratuberculosis* isolates were supplemented with 2 mg/L ferric mycobactin J (Allied Monitor Inc., Fayette, MO). All growth flasks were incubated at 37°C without shaking.

Table 3
Mycobacterial strains used

Isolate ^a	Source ^b	Origin	Additional Information
<i>M. avium</i> subsp. <i>paratuberculosis</i>			
ATCC 19698	ATCC	Bovine	Isolated from ileum in 1974; type strain
1434	NADC	Ovine	
1045	NADC	Bovine	Isolated from a Holstein lymph node in 1984
1112	NADC	Bovine	Isolated from an Angus lymph node in 1984
1018	NADC	Bovine	Isolated from a Holstein lymph node in 1983
KAY	NADC	Bovine	Isolated from a Holstein ileum in 1993
K-10	NADC	Bovine	Isolated from a Wisconsin dairy herd in 1990
1010	NADC	Bovine	
1113	NADC	Bovine	

<i>M. avium</i> subsp. <i>avium</i>			
236	NADC	Bovine	
WP21 CP (9-5-01)	NADC	Avian	Mycobactin J independent, isolated from a wood pigeon
6004 CP (10-16-01)	NADC	Chicken	ATCC 35719; TMC 801
1015	UMN	Deer	
1161	UMN	Avian	
1282	UMN	Human	
1285	UMN	Human	
<i>M. phlei</i>	NADC		
<i>M. smegmatis</i>	NADC		
<i>M. intracellulare</i>	NADC	Porcine	TMC 1472, 35773; <i>M. avium</i> - <i>M. intracellulare</i> - <i>M. scrofulaceum</i> complex 6
<i>M. fortuitum</i>	NADC		
<i>M. bovis</i>			
BCG Pasteur (8-11-01)	ATCC		ATCC 35734; TMC 1011
95 1398 (1998-1999)	NADC	Deer	Isolated from a Colorado feedlot
<i>M. tuberculosis</i> TB 14323		Human	

^a Dates of isolation (month/day/year) are in parentheses;

^b ATCC, American Type Culture Collection; NADC, National Animal Disease Center; UMN, University of Minnesota

5 Example 2 - Annotation of *M. paratuberculosis* contigs greater than 10 kb

The sequencing and assembly strategies used herein for *M. paratuberculosis* were as described for *Pasteurella multocida* (see May et al., 2001, *Proc. Natl. Acad. Sci. USA*, 98:3460-5). For these studies, assembled *M. paratuberculosis* contig fragments greater than 10 kb were chosen. Predicted coding sequences were identified using ARTEMIS software and TB-parse, a program used to identify coding sequences in the *M. tuberculosis* genome (Cole et al., 1998, *Nature*, 393:537-44). The results were compared and verified manually in ARTEMIS. A putative ribosome-binding site (RBS) was also evaluated for each coding sequence. The presence of an AG-rich sequence approximately 30-bp upstream of the start codon was scored as a putative RBS sequence. Similarities were identified with BLASTP analysis by using GenBank and a local database.

constructed by the Computational Biology Center at the University of Minnesota (<http://www.cbc.umn.edu>).

ARTEMIS and ACT are funded by the Wellcome Trust's Beowulf Genomics initiative and are available free on the internet at <http://www.sanger.ac.uk/Software/>.

5 Sequence alignments between *M. paratuberculosis* and *M. avium* were compared and visualized with ACT software. *M. avium* is being sequenced by The Institute for Genomic Research (TIGR; http://www.tigr.org/cgi-bin/BlastSearch/blast.cgi?organism=m_avium). Sequence alignments to produce figures or schematic illustrations were performed with AssemblyLIGN™ software (Accelrys, 10 Princeton, NJ).

The nucleotide sequence of each *M. paratuberculosis* gene described in this study was deposited individually in the GenBank/EMBL Nucleotide Sequence Data Library and were assigned GenBank Accession Nos. AF445420 through AF445446.

15 Example 3 - DNA hybridizations

Genomic DNA was extracted from several species of mycobacteria using a modified method from that described by Whipple et al. (Whipple et al., 1987, *J. Clin. Microbial.*, 25:1511-15). Briefly, one liter of Middlebrook 7H9 cultured mycobacteria was incubated at 37°C until an OD₅₄₀ of between 0.50 and 0.56 was reached. D- 20 Cycloserine was added to the media at a final concentration of 0.5 mg/ml and incubated an additional 24 h. Mycobacteria were harvested by centrifugation at 8,000 rpm for 15 min and the pellet was resuspended in 11 ml of Qiagen buffer B1 containing 1 mg/ml Qiagen RNase A. Lipase was added (450,000 Units, Sigma Catalog No L4384) to digest mycobacterial cell wall lipids. Following incubation for 2 h at 37°C, 20 mg of lysozyme 25 was added and incubation proceeded for an additional 3 h at 37°C. 500 µl of Qiagen proteinase K (20 mg/ml) was added and incubated for 1.5 h at 37°C. Qiagen buffer B2 (4 ml) was added and the slurry mixed and incubated 16 h at 50°C. The remaining cellular debris was removed by centrifugation at 10,000 rpm for 20 min. The supernatant was poured over a pre-equilibrated Qiagen 500/G genomic tip. The loaded column was 30 washed and processed according to the instructions of the manufacturer. *Pst*I restricted DNA fragments were separated on a 1% agarose gel. DNA-containing gels were

depurinated, denatured, and neutralized as described by Sambrook et al. (1989, *Molecular Cloning: A Laboratory Manual*, Second Ed., Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York). DNA was transferred by capillary action to BrightStar-Plus membranes (Ambion, Austin, TX) and probes were labeled using [α - 32 P]dCTP (ICN, Cost Mesa, CA) by random priming. Hybridization was performed in a AUTOBLOT hybridization oven (Bellco Biotechnology, Vineland, NJ) at 45°C for 16 h in ExpressHyb hybridization solution (Clontech, Palo Alto, CA). Probed blots were washed sequentially with solutions increasing in stringency as follows: 2 washes at room temp in 2X SSC, 0.1% SDS; 2 washes at room temp in 0.2X SSC, 0.1% SDS; and 2 washes at room temp in 0.16X SSC, 0.1% SDS. Detection was by autoradiography at room temp using BioMax MR film (Kodak, Rochester, NY) with a Kodak intensifying screen for less than 16 hours.

Example 4 - PCR amplification

Oligonucleotide primers listed in Table 4 were designed using the *M. paratuberculosis*-specific nucleic acid sequences identified herein. PCR amplification of *M. paratuberculosis*-specific nucleic acid molecules was performed as follows. A PCR master mix was generated that contained (each in final concentration) 1x AmpliTaq Gold buffer (Perkin-Elmer), 5% dimethylsulfoxide (DMSO, Sigma), 20 mM each nucleotide (Roche Biochemicals), 10 ng genomic DNA, and 1 Unit of AmpliTaq Gold DNA polymerase (Perkin-Elmer). Primers were added to individual PCR tubes containing 25 μ l of master mix. The PCR reaction conditions were as follows: a 5 min denaturing step at 94°C, followed by 35 cycles of: 94°C for 45 sec, 55°C for 1 min, and 72°C for 2 min. At the end of 35 cycles, there was a 7 min incubation at 72°C and a hold at 4°C. High fidelity *Pwo* polymerase (Boehringer Ingelheim Pharmaceutical Inc., Ridgefield, CT) was used in amplifications to generate probes used in Southern hybridization experiments. All other amplifications used Taq DNA polymerase (Roche Molecular Biochemicals, Indianapolis, IN).

Table 4
PCR primers used

Gene	Primer 1	SEQ ID NO:	Primer 2	SEQ ID NO:
10	CGGCGGATCAGCATCTAC	46	CACCTCATCGTGGCCAGGTT	47
11	ACCGAACACGAGTGGAGCA	48	CAGACTCTGACCGACGTCAT	49
38	GCATTTTCGGCTCCCACGGTG	50	TACGTCGGTTCGGCGCGCAT	51
56	ATGAACACTTCTTCCTCTCTA	52	CATATCGCGGTGATCCTGAC	53
57	ATGGCCACCAACGACGACCA	54	CGCGGCCGTTCGGGCCGGCTG	55
135	GCAGGCGTTTTCGCTTCTTG	56	CGAGGTCCGAAATAGCGTAG	57
159	ATGCGTTTCGCCCTCCCGAC	58	TCACGCCTTGATTTTCGTCTT	59
217	TGGCCGAACGCGGACTGTTC	60	TAGGAATCCGCGTCGACGAT	61
218	CAAGGTTCGTGACGGTATCG	62	TGACCCAGCAGGTATGGC	63
219	CATCTACTGAGCGCCGTTTG	64	CACGCCGCCACCCCGTCCCG	65
228	GCAAGGTGGGCTTTGAAG	66	TGCGTGGGAGGATAAGGC	67
240	TTGGCACTGGCGTTTATG	68	ACATCGGGAACACAGGTCTC	69
241	ATCCTCCGGTTTGGCGGGAA	70	ACAGAGGTCGATCGGGTCG	71
250	CAGTCGGCCGGCGAAACGCC	72	CGCGGCGAAATCGAACGC	73
251	CACGTGCTGTCCCCATCGGC	74	CTACGTCTTCGTGACCAAAG	75
252	TGACCACCGACAACCCACG	76	CATGAGGGCTGTCCCTCTCC	77
253	TTGACCGCGTTGACGGCGTT	78	CAGCGGTCCGCGCTCTTCGC	79
254	TGGGCAGCCCGGTGTCCCG	80	CACGCGCTCCTTTCAGCCTT	81
255	CAGTCACCCCGCGGCCGGTA	82	TCTACTGACCCGCAGATCGAA	83
256	TGGCCGTCAAGGACCAGAAC	84	CATGACCCTGCCGGCGTCCC	85
257	TGGCATTGGATCGCGTCGGA	86	TCAAACCCGGCGAGTTCTTC	87

Primers are shown in the 5' to 3' direction

- 5 Primers used to amplify the #7 sequence for a probe in Southern hybridizations were 5'-ATC AGG CTG ACG GGA TTG CCC-3' (SEQ ID NO:88) and 5'-TCA ACG AGT GCA CGG GAA CC-3' (SEQ ID NO:89).

10 Example 5 - Twenty-seven *M. paratuberculosis* predicted coding sequences are not present in *M. avium*

- 15 The complete genome of *M. paratuberculosis* K-10, a field isolate recovered from a cow with clinical Johne's disease, is currently being sequenced (<http://www.cbc.umn.edu/ResearchProjects/AGAC/Mptb/Mptbhome.html>). The genome size is estimated to be >5 Mb based on assembled sequence data, and by July, 2001, 2.65 Mb were contained in contig fragments greater than 10 kb. Those Contigs above 10 kb

were annotated using ARTEMIS and represent 48% of the total genome. The average size of the annotated contigs is 25 kb with one contig over 70 kb. Each gene within the annotated contig set was also checked manually and confirmed by TB-parse. These contigs were aligned with *M. avium* sequence data generated at TIGR. TIGR has 612
5 contigs that total 5,867,714 bp in the July 8, 2001 data set.

M. avium and *M. paratuberculosis* display a high degree of similarity at the nucleotide level as well as local gene order conservation. An analysis of an 11-kb region surrounding the origin of replication for each of these genomes shows 98% sequence identity at the nucleotide level. The sequence similarity between orthologs in *M.*
10 *paratuberculosis* and *M. avium* was greater than between *M. paratuberculosis* and other mycobacterial species. A more global comparison shows that these strong nucleotide identities are present throughout both genomes. Despite this strong genetic similarity, a total of 27 genes from the annotated *M. paratuberculosis* contigs were identified that did not align with the unfinished *M. avium* genome by computerized alignments. Of these,
15 three contained weak similarity to proteins in other mycobacterial species or proteins in GenBank. This left 24 genes that have no significant similarity to any known proteins. Since only about half of the *M. paratuberculosis* genome was used in these analyses, a complete genome analysis may reveal an estimated 50 unique *M. paratuberculosis* genes.

Some *M. paratuberculosis* sequences that did not align with *M. avium* sequences,
20 either *in silico* or experimentally, contain similarity to other mycobacterial species. One such sequence, designated #7, was tested by PCR and Southern hybridization with two *M. avium* isolates and two *M. paratuberculosis* strains. An amplified PCR fragment was produced only with *M. paratuberculosis* genomic DNA as template. Likewise, DNA hybridization on Southern blots detected only *M. paratuberculosis* sequences, not *M.*
25 *avium*. However, BLASTP analysis of the #7 sequence revealed strong similarity to hypothetical proteins in the *M. tuberculosis* genome.

Example 6 - PCR analysis

PCR amplification was performed on several mycobacterial species, strains and
30 isolates to experimentally determine the specificity for 26 of the 27 sequences (Table 5). Gene 128 was not included in these analyses because it had the lowest expect value

(highest similarity to a sequence in GenBank) of the 27 sequences by BLASTP analysis. These data show that primers designed from all 26 *M. paratuberculosis*-specific genes from isolate K-10 could produce an amplified product in all 10 *M. paratuberculosis* strains or isolates tested. In addition, despite an absence of any homologous sequences in public databases, PCR products of the correct size were obtained for five genes using template from other mycobacterial species. Following this analysis a core group of 21 genes remained that are present only in *M. paratuberculosis* (Table 5).

Example 7 - Sequence analysis of an *M. paratuberculosis*-specific eight gene cluster

Eight genes were present on contig fragment 1614. These eight genes are arranged in tandem, span a total of 4.4 kb at the end of the 1614 contig (Figure 1), and are present only in *M. paratuberculosis* (Table 5). 1408-bp upstream of gene 250 is an integrase gene that contains similarity to other mycobacteriophage integrases. This 4.4-kb segment (designated #481 (SEQ ID NO:23)) contains genes 250-257 and is located at the end of the 46-kb contig 1614. The sequences represented by #481 were found to align with the 94-kb contig 1398 present in a different contig assembly data set (Figure 1). The #481 sequence aligned near the center of the 94-kb contig, essentially at position 35 to 45 kb. A trimmed portion of the 1398 contig is shown in the alignment in Figure 1. The results of this analysis further extended the region of *M. paratuberculosis*-specific nucleic acid sequence to a 9.4-kb region, which does not align with *M. avium* sequence *in silico*.

Attorney Docket No.: 09531-112W01

Table 5. PCR analysis of *M. paratuberculosis* predicted coding sequences

Strain	Gene Number												
	56	57	159	217	218	228	240	250	251	252	253	254	255
<i>M. paratuberculosis</i>													
ATCC19698	+	+	+	+	+	+	+	+	+	+	+	+	+
1434	+	+	+	+	+	+	+	+	+	+	+	+	+
1045	+	+	+	+	+	+	+	+	+	+	+	+	+
1112	+	+	+	+	+	+	+	+	+	+	+	+	+
1018	+	+	+	+	+	+	+	+	+	+	+	+	+
Kay	+	+	+	+	+	+	+	+	+	+	+	+	+
K-10	+	+	+	+	+	+	+	+	+	+	+	+	+
1010	+	+	+	+	+	+	+	+	+	+	+	+	+
1113	+	+	+	+	+	+	+	+	+	+	+	+	+
<i>M. avium</i>													
#236	-	-	-	-	-	-	-	-	-	-	-	-	-
WP21	-	-	-	-	-	-	-	-	-	-	-	-	-
TMC801	-	-	-	-	-	-	-	-	-	-	-	-	-
1015	-	-	-	-	-	-	-	-	-	-	-	-	-
1161	-	-	-	-	-	-	-	-	-	-	-	-	-
1282	-	-	-	-	-	-	-	-	-	-	-	-	-
1285	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>M. phlei</i>													
<i>M. smegmatis</i>	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>M. intracellulare</i>	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>M. fortuitum</i>	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>M. bovis</i> BCG	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>M. bovis</i> 95-1398	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>M. tuberculosis</i>	-	-	-	-	-	-	-	-	-	-	-	-	-

Attorney Docket No.: 09531-112W01

Table 5 - Continued

Table 5 - Continued												
	Strain	Gene Number										
		10	11	38	48	49	50	93	134	135	219	241
5	<i>M. paratuberculosis</i>											
	ATCC19698	+	+	+	+	+	+	+	+	+	+	+
	1434	+	+	+	+	+	+	+	+	+	+	+
	1045	+	+	+	+	+	+	+	+	+	+	+
	1112	+	+	+	+	+	+	+	+	+	+	+
10	1018	+	+	+	+	+	+	+	+	+	+	+
	Kay	+	+	+	+	+	+	+	+	+	+	+
	K-10	+	+	+	+	+	+	+	+	+	+	+
	1010	+	+	+	+	+	+	+	+	+	+	+
	1113	+	+	+	+	+	+	+	+	+	+	+
15	<i>M. avium</i>											
	#236	-	-	-	-	-	-	+	+	-	-	-
	WP21	-	-	-	+	+	+	+	+	-	-	-
	TMC801	-	-	-	+	+	+	+	+	-	-	-
	1015	-	-	-	+	+	+	+	+	-	-	-
20	1161	-	-	-	+	+	-	+	+	-	-	-
	1282	-	-	-	-	-	-	+	+	-	-	-
	1285	-	-	-	-	-	-	+	+	-	-	-
	<i>M. phlei</i>	-	-	-	-	-	-	-	+	-	-	-
	<i>M. smegmatis</i>	-	-	-	-	-	-	-	-	-	-	-
25	<i>M. intracellulare</i>	-	-	-	+	+	+	+	-	-	-	-
	<i>M. fortuitum</i>	-	-	-	-	-	-	-	-	-	-	-
	<i>M. bovis</i> BCG	-	-	-	-	+	-	-	-	-	-	-
	<i>M. bovis</i> 95-1398	-	-	-	-	+	-	-	-	-	-	-
	<i>M. tuberculosis</i>	-	-	-	+	-	-	-	-	-	-	-
30	"+" indicates that an amplification product of the correct size was detected by ethidium bromide staining. "- " indicates that no amplification product was detected by ethidium bromide staining.											

"4" indicates that an amplification product of the correct size was detected by ethidium bromide staining.

"-" indicates that no amplification product was detected by ethidium bromide staining.

A TBLASTX analysis was performed on the 9.4-kb sequence (designated contig 1398-trimmed in Figure 1). The results of these analyses revealed that, while no sequences aligned with *M. avium*, the ends of contig 1398-trimmed align with sequences in *M. tuberculosis*. This leaves a core sequence of eight ORFs within the #481 sequence that are present only in *M. paratuberculosis*. This core sequence is flanked by 1408 bp of non-coding sequence downstream and 1092-bp of non-coding sequence upstream (Figure 1). Therefore, this novel core sequence is well separated from other predicted open reading frames.

10 Example 8 - Southern hybridization analysis shows that the #481 sequence is specific to *M. paratuberculosis*

To confirm experimentally that #481 is present only in *M. paratuberculosis*, three arbitrarily chosen genes of the #481 sequence (251, 253, and 255) were radiolabeled and used as probes in DNA hybridization with several mycobacterial species including *M. fortuitum*, *M. bovis*, *M. intracellulare*, *M. avium*, and *M. paratuberculosis*. Following Southern blotting, only a *M. paratuberculosis* fragment greater than 9.5 kb was detected by each of the three probes.

20 Example 9 - Characteristics of *M. paratuberculosis*-specific polypeptides

The characteristics of *M. paratuberculosis*-specific polypeptides shown in Table 6 were obtained using MacVector sequence analysis software (Oxford Molecular).

Table 6
Characteristics of *M. paratuberculosis*-specific polypeptides

Gene	pI	MW (Da)
10	5.29	36,380
11	5.12	21,826
38	9.51	18,730
56	9.32	21,116
57	3.90	10,417
128	9.96	20,772
135	11.58	17,018
159	11.47	20,655
217	10.49	11,567
218	11.05	91,530

Gene	pI	MW (Da)
219	12.05	10,004
228	12.30	40,817
240	9.14	24,949
241	9.17	13,509
250	4.40	21,434
251	5.54	19,500
252	3.87	9,687
253	11.50	7,881
254	8.38	16,262
255	7.36	25,851
256	7.17	15,120
257	5.48	9,358

Example 10 - Expression of *M. paratuberculosis* genes in *E. coli*

To confirm coding predictions of novel *M. paratuberculosis* genes and assess their immunogenicity, coding sequences were amplified from the genome by PCR and cloned into the pMAL-c2 *E. coli* expression plasmid. These proteins were expressed as a fusion with *E. coli* maltose binding protein (MBP) to enable affinity purification on an amylose resin column. An immunoblot was probed with a monoclonal antibody that binds MBP, which identified each fusion protein. A duplicate immunoblot was probed with polyclonal sera from a rabbit immunized with a heat-killed preparation of *M. paratuberculosis*. Only the fusion protein containing the *M. paratuberculosis* specific polypeptide produced from gene 253 was detected by the rabbit sera, indicating that the polypeptide encoded by gene 253 was produced by *M. paratuberculosis*. The MBP protein was not detected by the polyclonal sera.

Example 11 - The psp-1 gene product is recognized by sera from cattle with Johne's disease

The polypeptide produced from gene 253 was termed psp-1 (paratuberculosis-specific protein). To determine if psp-1 is recognized during infection of cattle, the purified MBP/psp-1 fusion was evaluated further by immunoblot with sera from cattle with overt signs of Johne's disease. Sera from all three Johne's cows examined recognized the MBP/psp-1 fusion protein but did not recognize MBP alone. Another *M.*

paratuberculosis-MBP fusion protein using gene 251 was also evaluated in this experiment, but the fusion protein produced therefrom was only weakly detected.

Immunoblot analysis of psp-1 was further expanded to include additional sera from John's cattles as well as control cattle housed at NADC and a local Iowa dairy herd. The polypeptide designated psp-1 was not detected by sera from 7 control cows, but was detected by 14 of 16 John's cows tested.

Example 12 - Expression of *M. paratuberculosis* coding sequences

Coding sequences within *M. paratuberculosis*-specific DNA fragments are cloned into *E. coli* expression vectors (e.g., containing a sequence encoding a 6x His tag). Heterologously expressed mycobacterial proteins are affinity purified from *E. coli* lysates by a polyhistidine tag. These purified proteins are then evaluated serologically with a panel of sera from infected and control cows to determine if the protein is recognized by sera from infected animals.

Specifically, each open reading frame identified as unique to *M. paratuberculosis* is amplified from genomic DNA, cloned into the pCRT7 expression vector (Invitrogen), and transformed into *E. coli* DH5- α . Each of the constructs are verified by DNA sequence analysis. The level of expression of the gene of interest is evaluated by loading the recombinant *E. coli* lysates onto SDS-PAGE gels and staining them in Coomassie blue. Expressed proteins are purified from *E. coli* lysates using the vector-encoded polyhistidine tag that has affinity for metal ions. Column purification using TALON metal resin (Clontech) is used. The fusion alone is used as a negative control. Comparisons of the reactivity of a collection of cattle antisera with the fusion proteins are conducted using a slot-blotting device (BioRad). Lysates of recombinant *E. coli* are loaded onto preparative 12% (w/v) polyacrylamide gels and transferred to nitrocellulose. After blocking, these filters are placed into the slot-blot device. Individual cattle antisera, each diluted 1:200, is added to independent slots. The rest of the procedure is carried out using standard immunoblot protocols. Protein G-peroxidase diluted 1:25,000 or anti-bovine IgG-peroxidase diluted 1:20,000 are used for detection of bound antibody.

Example 13 - Production of monoclonal and polyclonal antibodies against *M. paratuberculosis*-specific polypeptides

All expressed and purified *M. paratuberculosis*-specific polypeptides are used to immunize both BALB/c mice and New Zealand white rabbits. Standard immunization regimens are used in each instance. TiterMax or Freund's incomplete serve as the adjuvant. Splenic lymphocytes from the immunized mice are hybridized with myeloma cells for the production of monoclonal antibodies. ELISA is the method used to assay secreting hybridomas for reactivity to purified antigens. Hybridomas in positive wells are cloned and expanded using standard methods. Rabbit antisera is collected following boost injections of isolated polypeptide until a sufficient titer is obtained.

Example 14 - ELISA assays

Improvement in the specificity of the ELISA test for detection of animals with Johne's disease has always been a major goal. The only test commercially available in the US is a direct test that uses a protoplasmic antigen preparation (Dubash et al., 1995, *J. Vet. Diag. Invest.*, 7:347-51; Collins & Sockett, 1993, *J. Am. Vet. Med. Assoc.*, 203:1456-63). Efforts to amplify antigen/antibody reactions focus on the use of an indirect biotin/avidin system. The purified *M. paratuberculosis*-specific polypeptide to be evaluated is diluted in PBS and added to 96-well microtiter plates. Plates with bound polypeptide are blocked in PBS containing 1% gelatin and then washed three times with PBS containing 0.05% Tween. Test cattle sera is diluted 1:400 in PBS, added to individual wells, and processed as a standard ELISA. Mouse anti-bovine IgM or mouse anti-bovine IgG is the second antibody in these assays. Results show that the use of a biotinylated second antibody followed by streptavidin/alkaline phosphatase and enzyme detection enhances test sensitivity 8 to 16-fold (based on antibody titers) as compared to the standard direct ELISA.

The method described herein using a *M. paratuberculosis*-specific polypeptide is compared to the commercially available direct ELISA by determining antibody titers of sera from clinically affected animals. Sera selected for these evaluations will include samples from both clinical and subclinical animals at NADC and from a nearby dairy herd (State Center, IA) shown to have Johne's disease. For all evaluations, it is necessary

to include samples from known negative animals to assess specificity. In addition, because of potential cross-reactivity that may be encountered with other bacteria, especially other mycobacteria, sera from animals known to be naturally or experimentally infected with other mycobacterial, particularly *M. avium*, are included. These controls
5 determine whether the ELISA test detects only *M. paratuberculosis*-infected cattle.

Example 15 - Use of antibodies against *M. paratuberculosis*-specific polypeptides in immunohistochemical diagnosis of infected bovine tissues

Histopathologic analysis of tissues from infected animals is a rapid method of
10 detecting *M. paratuberculosis*. Biopsy tissue or tissue samples taken at necropsy are stained for acid-fastness to determine the presence of *M. paratuberculosis*. However, this method is non-specific and does not distinguish among mycobacterial species. Therefore, bovine tissues from *M. paratuberculosis*-, *M. bovis*-, *M. avium*-infected and uninfected animals are tested by histopathologic analysis using high-titer antibodies directed at *M.*
15 *paratuberculosis*-specific polypeptides. Briefly, samples from the ileum and mesenteric lymph node of cows are fixed in buffered formalin, processed routinely, and embedded in paraffin wax. 6 µm cut sections are stained with hematoxylin and eosin or Ziehl-Neelsen by conventional methods. Replicate unstained sections will be prepared for immunohistochemistry. Sections that are immunostained are deparaffinized, rehydrated
20 and blocked using routine methods (Stabel et al., 1996, *J. Vet. Diagn. Invest.*, 8:469-73). Blocked sections are incubated with *M. paratuberculosis*-specific antibodies developed in the above-described studies. Depending on the nature of the primary antibody, either goat anti-rabbit biotinylated antibody or goat anti-mouse biotinylated antibody is added followed by washing instreptavidin-alkaline phosphatase solution. The tissue is stained
25 with chromogen, and Histomark Red. Results are visualized under a bright-field microscope. Staining intensities are quantitatively compared among the different infected and uninfected tissues.

Example 16 - Detection of *M. paratuberculosis* by PCR amplification

30 Detection of *M. paratuberculosis* using oligonucleotide primers complementary to *M. paratuberculosis*-specific genes 93, 135, 218, 228, 240, and 251 or oligonucleotide

primers complementary to IS900 nucleic acid sequences was examined by PCR. IS900 primer sequences were as follows: 5'-AAT CAA CTC CAG CAG CGC GGC CTC G-3' (SEQ ID NO:108) and 5'-CCG CTA ATT GAG AGA TGC GAT TGG-3' (SEQ ID NO:109). Fourteen fecal samples were processed from cattle in various stages of shedding. The bacterial load being shed by each animal was determined by culture on 7H10 slants.

To detect *M. paratuberculosis* by amplification of nucleic acids from a biological sample, a PCR master mix was generated similar to that described in Example 4 with the addition to the master mix of 10 mM MgCl. The PCR reaction conditions for amplification of nucleic acids from a biological sample were as follows: a 10 min denaturing step at 94°C, followed by 50 cycles of: 94°C for 59 sec, 60°C for 30 sec, and 72°C for 1 min. At the end of 50 cycles, there was a 10 min incubation at 72°C followed by a hold at 4°C.

Results of the PCR assays are as follows. Seven cattle identified as shedding heavily were all positive for *M. paratuberculosis* nucleic acid using either IS900 or MP228 primers. Out of 5 cattle identified as medium shedders, primers directed toward IS900 detected *M. paratuberculosis* nucleic acid in 1 animal, while primers directed toward MP228 detected *M. paratuberculosis*-specific nucleic acid in 2 animals. Out of 2 cattle identified as low shedders, primers directed toward IS900 detected *M. paratuberculosis* nucleic acid in 1 animal, while MP228 primers didn't detect *M. paratuberculosis*-specific nucleic acid in any animal. In titrations of *M. paratuberculosis* genomic DNA (isolate K-10), IS900 nucleic acids were detectable in 1 fg of nucleic acid, while each of the *M. paratuberculosis*-specific nucleic acids were detectable in 10 fg of nucleic acid.

Table 7
Primers used in PCR amplifications

Primer Name	Primer sequence	SEQ ID NO:	Gene
MP93F	5'-TTGCTGCGGGAAGGTTGCC-3'	90	93
MP93B	5'-CGAGAACGAGATGTGCGTCAG-3'	91	

Primer Name	Primer sequence	SEQ ID NO:	Gene
MP135F	5'-GCAGGCGTTTGCGTTCTTG-3'	92	135
MP135B	5'-CGAGGTCCGAAATAGCGTAGG-3'	93	
MP218F	5'-CCAAGGTTCGTGACGGTATCG-3'	94	218
MP218B	5'-TGACCCAGCAGGTATGGC-3'	95	
MP228F	5'-GCAAGGTGGGCTTTGAAG-3'	96	228
MP228B	5'-TGCGTGGGAGGATAAGGC-3'	97	
MP240F	5'-TTGGCACTGGCGTTTATG-3'	98	240
MP240B	5'-ACATCGGGAACACAGGTCTC-3'	99	
MP251F	5'-ATGCCTACGGTTCGGTGC-3'	100	251
MP251B	5'-AAGACAGCGTCAGCCAGC-3'	101	

Example 17—Analysis of the *M. paratuberculosis* genome

A shotgun strategy was adopted to sequence the genome of *M. paratuberculosis* strain K-10. To create a small (1.5- to 3.0-kb) insert library, genomic DNA was isolated using a chloroform/cetyltrimethylammonium bromide-based method and DNA was sheared by nebulization and cloned into a pUC18 plasmid vector for shotgun sequence analyses essentially as described (May et al., 2001, *Proc. Natl. Acad. Sci., USA*, 98:3460-5). Approximately 24,000 clones were sequenced from both ends using Dye-terminator chemistry on ABI 3700 and 3100 (Applied Biosystems) sequencing machines and a total of 45,653 sequences (representing ~ 7.8-fold coverage of the genome) were generated in this manner for inclusion in the final sequence assembly. Sequence assembly and verification were accomplished by using the phredPhrap and Consed suite of software (<http://genome.washington.edu>). In order to close the final ~400 gaps at the end of the shotgun phase, several methods were used, including primer walking and random PCR. The final sequence showed that the *M. paratuberculosis* genome was a single circular chromosome of 4,830,869 bp and an average GC content of 69.3%.

The sequence of the entire *M. paratuberculosis* genome (SEQ ID NO:1355) is shown in Table 8 (contained on the appended compact disc, which has been incorporated by reference herein).

The resulting approximately 24,000 nucleic acid segments were analyzed as follows. Each of the 24,155 segments was compared to the *M. avium* genome using BLASTN (released May 14, 2002). 23,056 segments had homology to *M. avium* sequences, while 1,099 segments had no homology with sequences in the *M. avium* database. Of the 23,056 segments having homology to *M. avium* sequences, 22,558 segments had >50% sequence identity to *M. avium* sequences, while 498 segments possessed <50% sequence identity to *M. avium* sequences. The 498 segments having <50% sequence identity to *M. avium* sequences were then compared to sequences in the GenBank database (having a release date of December 28, 2002) using BLASTN. Of the 498 segments used in the BLASTN comparison, 130 segments were identified as having <50% sequence identity with sequences in the GenBank database, while 277 segments had no sequence identity with sequences in the GenBank database. Those 407 segments (277 segments + 130 segments) were considered to be *M. paratuberculosis*-specific nucleic acids. The 1,099 segments that had no homology to *M. avium* sequences were then compared to the GenBank database using the BLASTN. 702 segments had no homology with sequences in GenBank, while 397 segments possessed homology with sequences in the GenBank database. Of those 397 segments, 29 segments exhibited <50% sequence identity with sequences in the GenBank database, while 95 segments exhibited sequence identity with *M. paratuberculosis* sequences that were previously submitted to the GenBank database. Those 825 segments (702 segments + 29 segments + 95 segments) were also considered to be *M. paratuberculosis*-specific nucleic acids.

The positions of these *M. paratuberculosis*-specific nucleic acids are schematically shown in Figure 5. The sequences of the resulting 1,232 *M. paratuberculosis*-specific nucleic acids are shown in Figure 6 (SEQ ID NOs:110-1342). As can be seen from the numerical designations of the 1,232 segments (Figure 6), many of the 200 nucleotide segments are contiguous. Therefore, any number of contiguous segments can be joined to generate a longer *M. paratuberculosis*-specific nucleic acid.

Potential coding sequences (CDSs) in the genome were predicted by using GLIMMER, and ARTEMIS, and the results were compared and verified manually in ARTEMIS. Homology studies using the predicted polypeptide sequence were completed with BLASTP analysis by using customized sequence databases constructed by the
5 Computational Biology Center at the University of Minnesota (<http://www.cbc.umn.edu>). Table 9 (contained on the appended compact disc, which has been incorporated by reference herein) describes the annotation of the *M. paratuberculosis* genomic sequences, and Table 10 (contained on the appended compact disc, which has been incorporated by reference herein) describes the predicted amino acid sequences encoded by each
10 identified coding sequence.

Example 18 - DNA isolation from bacterial culture and fecal samples

A total of 161 bacterial isolates were used in these studies, including *M. paratuberculosis* (n = 118), *M. avium* (n = 21), and other mycobacterial and non-
15 mycobacterial species (n = 22). See Table 11. *M. paratuberculosis* strain K-10 was used as the standard strain. *M. paratuberculosis* isolates were grown on Middlebrook 7H9 broth or 7H11 agar (Difco Laboratories, Detroit, MI) with OADC supplement (Becton Dickinson, Sparks, MD) and mycobactin J (2 mg/100 ml), and cultures were incubated at 37°C for 4-6 months until colonies were observed. *M. avium* isolates were grown on
20 Middlebrook 7H9 broth without mycobactin J and cultures were incubated at 37°C for 2 weeks. Other mycobacterial and non-mycobacterial species were grown on LB medium and incubated overnight at 37°C.

DNA was isolated from bacterial cultures using the QIAamp DNA Mini Kit (QIAGEN Inc., Valencia, CA). Briefly, bacteria were pelleted and resuspended in 180 µl
25 Buffer ALT. Proteinase K (20 µl) was added, and the samples were vortexed and incubated at 56°C for 10 minutes. After addition of 200 µl Buffer AL, the samples were incubated at 70°C for 10 minutes. Ethanol (200 µl) was added and the samples were vortexed and loaded onto spin columns, which were subjected to centrifugation at 8000 rpm for 1 minute. The columns were washed with 500 µl Buffer AW and the DNA was
30 eluted in 50 µl distilled water.

Table 11
Mycobacterium isolates tested

Bacteria	Source	n
<i>M. paratuberculosis</i>	Human	3
	Ovine	7
	Bovine	99
	Murine	1
	Caprine	6
	Unknown	2
<i>M. avium</i>		21
<i>M. intracellulare</i>		1
<i>M. scrofulaceum</i>		1
<i>M. phlei</i>		1
<i>M. smegmatis</i>		1
<i>M. sylvaticum</i>		1
<i>M. fortuitum</i>		1
<i>Atypical mycobacteria</i>		4
<i>Uncharacterized non-MAP</i>		9
<i>Salmonella</i> spp.		2
<i>S. aureus</i>		1
Total:		161

5 The QIAamp DNA Stool Mini Kit (QIAGEN Inc.) was used to isolate DNA from stool samples. Briefly, 1.4 ml Buffer ASL was added to 200 mg of sample (1 gm of sample can be used with 10X Buffer ASL). The mixtures were vortexed, heated at 95°C for 5 minutes, and pelleted to remove stool particles, and 1.2 ml of each resulting supernatant was transferred to a new 2 ml tube. An InhibitEX tablet was added to each

10 sample, and the tubes were vortexed and then incubated for 1 minute at 25°C. The mixtures were pelleted and 15 µl of Proteinase K was added to 200 µl of each supernatant. Buffer AL (200 µl) was added and the samples were incubated at 70°C for 10 minutes. After addition of 200 µl ethanol, samples were vortexed and loaded onto spin columns. The columns were subjected to centrifugation at 8000 rpm for 1 minute

15 and then washed two times with 500 µl Buffer AW1 and Buffer AW2. DNA was eluted in 50 µl distilled water.

Example 19 – Real-time PCR

A PCR master mix was prepared containing the following: 1X TaqMan Buffer A (Perkin Elmer), 5.0 mM MgCl₂, 1.25 units per reaction Amplitaq Gold, 200 μM dATP, 200 μM dCTP, 200 μM dGTP, 400 μM dUTP, 5% DMSO, 0.01 units per reaction UNG, 100 μM of each primer, and 150 μM of each probe. Five μl of template DNA was placed in each PCR reaction tube, and 45 μl of Master mix was added. PCR samples were subject to initial denaturation at 50°C for 10 minutes and then at 95°C for 10 minutes; 40 amplification cycles of 94°C for 30 seconds, 60°C for 30 seconds, and 72°C for 1 minute; a final extension at 72°C for 7 minutes; and a soak at 25°C. Specific PCR products were detected using the ABI Prism 7700 or 7900HT Sequence Detection System (Applied Biosystems, Inc.). Results were recorded as Delta-RQ, which is the difference in the Rn values from the samples and the no-template control. The Rn values are the ratio of reporter emission to quencher emission. Agarose gel electrophoresis with ethidium bromide staining was performed to verify the results of the TaqMan assay. All assays were performed in duplicate.

To evaluate the sensitivity of the assay, ten-fold dilutions of *M. paratuberculosis* strain K-10 cells were spiked into a negative fecal sample collected from a known *M. paratuberculosis*-free dairy farm. *M. paratuberculosis* DNA amounts ranged from 100 ng to 1 fg, equivalent to 112900 to 0.0011 molecules/reaction. DNA was extracted from the spiked samples using a QIAamp DNA Stool Mini Kit, the sensitivity of the assay for detecting *M. paratuberculosis* in fecal samples was assessed by PCR as described above.

The specificity of the assay was evaluated using template DNA from other mycobacteria (*n*=48), and non-mycobacterial spp. (*n*=3). In addition, the TaqMan assay was compared to conventional PCR, which was performed using primer sequences complimentary to SR134 (see Table 12).

Table 12
Primer and probe sequences

Primer/Probe	Sequence	SEQ ID NO:
TaqMan		
SR134-236F	5'GTGGTGCAGCCAATGGTTG	1343

SR134-427R	5'GGACGCAAACCTCACCCCTTCAT	1344
SR134-1437F	5'TTTCCAGCGCAGATCGAAA	1345
SR134-1633R	5'ACAGCATGTTTGCGTTCCTG	1346
Probe		
SR134-273T	5'6FAM-TAGCGGACCTTGCGGTTGCCG-TAMRA	1347
SR134-1479T	5'6FAM-ATCCGAAAAACCGTGCAGGGCC-TAMRA	1348
Conventional PCR		
SR134-2-F	5'GTGTTGTAGTCAGACCCTGTGG	1349
SR134-2-R	5'AAAAACAACCATTTGGCTGCAC	1350
SR134-3-F	5'TGGATATGAAGGGTGAGTTTGC	1351
SR134-3-R	5'GATCAAACCGCTACCGCTAC	1352
SR134-5-F	5'TCAACGTCGTCGAATGAAAC	1353
SR134-5-R	5'TGTTTCCCGAGGAGATGTTC	1354

Example 20 – Use of real-time PCR for detection and quantitation of *M. paratuberculosis*

A real-time PCR assay was developed for detection and quantitation of *M. paratuberculosis*. Primers and probes were designed based on a novel unique sequence, SR134 (Table 11). SR134 is a sequence unique to *M. paratuberculosis* and is present in 6 copies in the genome. To increase sensitivity, two sets of primer-probe combinations were tested and used in the TaqMan assay as a multiplex strategy to amplify 211 bp and 215 bp fragments of the *M. paratuberculosis* SR134 sequence. Assay conditions were optimized for MgCl₂, primer, and probe concentrations in the reaction mix; optimal concentrations were found to be 5.0 mM MgCl₂, 100 nM each primer, and 150 nM each probe.

To quantitate standard *M. paratuberculosis*, curves resulting from amplification of SR134 from known amounts of *M. paratuberculosis* DNA (100 ng to 1 fg) were generated. A regression line was generated from the data points, and the correlation coefficient (R^2) value was determined to be 0.99. The ability to employ the TaqMan approach for quantitation of *M. paratuberculosis* also was determined. For example, a sample containing a “blinded” number of *M. paratuberculosis* cells had a Ct value of 24.16, which was equivalent to 0.082 ng DNA or 96 cell equivalents, and closely approximates the 100 cell equivalents that were spiked into the sample.

Known amounts of *M. paratuberculosis* K-10 genomic DNA were used to test the sensitivity of the assay. DNA concentrations ranging from 100 ng to 1 fg resulted in Ct values of 15.18 to 39.09. The cut-off point for accurate detection of *M. paratuberculosis* K-10 DNA was approximately 100 fg of DNA (35.04 Ct), which represents 0.11 cell
5 equivalents of *M. paratuberculosis*. Ten-fold dilutions of *M. paratuberculosis* K-10 cells spiked in feces also were used to determine the sensitivity of the assay. The assay was reliably able to detect 1 cell of *M. paratuberculosis* per PCR reaction.

The specificity of the TaqMan assay was tested using 118 *M. paratuberculosis* isolates from different animal species including bovine, ovine, murine, and humans,
10 isolates representing 7 other mycobacterial species (n=27) including the closely related *Mycobacterium avium*, atypical mycobacteria (n=4), and uncharacterized non-MAP (n=9) (Table 11). The SR134 TaqMan assay was able to detect all but two *M. paratuberculosis* isolates, whereas no amplification was observed with any of the other mycobacterial and non-mycobacterial species. Thus, this assay was 100% specific for amplification of *M.*
15 *paratuberculosis* DNA.

OTHER EMBODIMENTS

It is to be understood that while the invention has been described in conjunction
20 with the detailed description thereof, the foregoing description is intended to illustrate and not limit the scope of the invention, which is defined by the scope of the appended claims. Other aspects, advantages, and modifications are within the scope of the following claims.

WHAT IS CLAIMED IS:

1. An isolated nucleic acid, wherein said nucleic acid comprises a nucleic acid molecule of 10 nucleotides to 969 nucleotides, said molecule having at least 75%
5 sequence identity to SEQ ID NO:1 or to the complement of SEQ ID NO:1, wherein any said molecule that is 10 to 35 nucleotides in length, under standard amplification conditions, generates an amplification product from *M. paratuberculosis* nucleic acid using an appropriate second nucleic acid molecule, but does not generate an amplification product from nucleic acid of any of the organisms selected from the group consisting of
10 *Homo sapiens*, *Pseudomonas aeruginosa*, *Streptomyces viridochromogenes*, *Mus musculus*, *Felis catus*, and *Xanthomonas campestris* using an appropriate third nucleic acid molecule.
2. The nucleic acid of claim 1, wherein said nucleic acid molecule has the
15 sequence shown in SEQ ID NO:1.
3. The nucleic acid of claim 1, wherein said nucleic acid molecule has at least 75% sequence identity to SEQ ID NO:1.
- 20 4. The nucleic acid of claim 3, wherein the nucleic acid molecule has the sequence shown in SEQ ID NO:102.
5. The nucleic acid of claim 1, wherein said nucleic acid molecule has at least 80% sequence identity to SEQ ID NO:1.
25
6. The nucleic acid of claim 5, wherein said nucleic acid molecule has the sequence shown in SEQ ID NO:103.
7. The nucleic acid of claim 1, wherein said nucleic acid molecule has at least
30 85% sequence identity to SEQ ID NO:1.

8. The nucleic acid of claim 7, wherein said nucleic acid molecule has the sequence shown in SEQ ID NO:104.

9. The nucleic acid of claim 1, wherein said nucleic acid molecule has at least
5 90% sequence identity to SEQ ID NO:1.

10. The nucleic acid of claim 9, wherein said nucleic acid molecule has the sequence shown in SEQ ID NO:105.

10 11. The nucleic acid of claim 1, wherein said nucleic acid molecule has at least 95% sequence identity to SEQ ID NO:1.

12. The nucleic acid of claim 11, wherein said nucleic acid molecule has the sequence shown in SEQ ID NO:106.

15

13. The nucleic acid of claim 1, wherein said nucleic acid molecule has at least 99% sequence identity to SEQ ID NO:1.

14. The nucleic acid of claim 13, wherein said nucleic acid molecule has the
20 sequence shown in SEQ ID NO:107.

15. A vector comprising the nucleic acid of claim 1.

16. A host cell comprising the vector of claim 15.
25

17. An isolated polypeptide encoded by the nucleic acid of claim 1.

18. The isolated polypeptide of claim 17, wherein said polypeptide has the amino acid sequence shown in SEQ ID NO:24.
30

19. An article of manufacture, wherein said article of manufacture comprises the polypeptide of claim 17.

20. An antibody, wherein said antibody has specific binding affinity for the polypeptide of claim 17.

21. A method for detecting the presence or absence of *M. paratuberculosis* in a biological sample, comprising the steps of:
contacting said biological sample with one or more of the nucleic acids of claim 1 under standard amplification conditions, wherein an amplification product is produced if *M. paratuberculosis* nucleic acid is present in said biological sample; and detecting the presence or absence of said amplification product, wherein the presence of said amplification product indicates the presence of *M. paratuberculosis* in the biological sample, and wherein the absence of said amplification product indicates the absence of *M. paratuberculosis* in the biological sample.

22. The method of claim 21, wherein said biological sample is derived from a cow, a sheep, a goat, a rabbit, a deer, an antelope, a bison, or a human.

20

23. The method of claim 21, wherein said biological sample is a fecal sample or a milk sample.

24. The method of claim 21, wherein said one or more nucleic acids comprise a nucleic acid sequence selected from the group consisting of SEQ ID NO:46 and SEQ ID NO:47.

25

25. A method for detecting the presence or absence of *M. paratuberculosis* in a biological sample, comprising the steps of:

contacting said biological sample with one or more of the nucleic acids of claim 1 under hybridization conditions, wherein a hybridization complex is produced if *M. paratuberculosis* nucleic acid is present in said biological sample; and

detecting the presence or absence of said hybridization complex,

5 wherein the presence of said hybridization complex indicates the presence of *M. paratuberculosis* in said biological sample, and wherein the absence of said hybridization complex indicates the absence of *M. paratuberculosis* in said biological sample.

10 26. The method of claim 25, wherein nucleic acids present in said biological sample are electrophoretically separated.

27. The method of claim 26, wherein said electrophoretically separated nucleic acids are attached to a solid support.

15

28. The method of claim 27, wherein said solid support is a nylon membrane or a nitrocellulose membrane.

29. The method of claim 25, wherein said one or more nucleic acids are
20 labeled.

30. The method of claim 25, wherein said biological sample is selected from the group consisting of a fecal sample, a milk sample, and a blood sample.

25 31. A method for detecting the presence or absence of *M. paratuberculosis* in a biological sample, comprising the steps of:

contacting said biological sample with the polypeptide of claim 17, wherein a polypeptide-antibody complex is produced if an antibody having specific binding affinity for said polypeptide is present in said sample; and

30 detecting the presence or absence of said polypeptide-antibody complex,

wherein the presence of said polypeptide-antibody complex indicates the presence of *M. paratuberculosis* in said biological sample, and wherein the absence of said polypeptide-antibody complex indicates the absence of *M. paratuberculosis* in said biological sample.

5

32. The method of claim 31, wherein said polypeptide is attached to a solid support.

33. The method of claim 31, wherein said biological sample is selected from
10 the group consisting of a blood sample or a milk sample.

34. A method for detecting the presence or absence of *M. paratuberculosis* in a biological sample, comprising the steps of:

contacting said biological sample with the antibody of claim 20, wherein
15 an antibody-polypeptide complex is produced if a polypeptide is present in said biological sample for which said antibody has specific binding affinity, and

detecting the presence or absence of said antibody-polypeptide complex,
wherein the presence of said antibody-polypeptide complex indicates the presence of *M. paratuberculosis* in said biological sample, and wherein the absence of
20 said antibody-polypeptide complex indicates the absence of *M. paratuberculosis* in said biological sample.

35. The method of claim 34, wherein said antibody is bound to a solid support.

25 36. The method of claim 34, wherein said biological sample is selected from the group consisting of a blood sample or a milk sample.

37. A method of preventing infection by *M. paratuberculosis* in an animal, comprising the steps of:

30 administering a compound to said animal, wherein said compound comprises the polypeptide of claim 17,

wherein said compound immunizes said animal against *M. paratuberculosis*.

38. A method of preventing infection by *M. paratuberculosis* in an animal,
5 comprising the steps of:

administering a compound to said animal, wherein said compound
comprises the nucleic acid of claim 1,

wherein said compound immunizes said animal against *M. paratuberculosis*.

10

39. An isolated nucleic acid, wherein said nucleic acid comprises a nucleic acid molecule of at least 10 nucleotides, said molecule having at least 75% sequence identity to a sequence selected from the group consisting of SEQ ID NOs:1-22 and SEQ ID NO:23 or to the complement a sequence selected from the group consisting of SEQ ID
15 NOs:1-22 and SEQ ID NO:23, wherein any said molecule that is 10 to 30 nucleotides in length, under standard amplification conditions, generates an amplification product from *M. paratuberculosis* nucleic acid using an appropriate second nucleic acid molecule, but does not generate an amplification product from nucleic acid of any of the organisms selected from the group consisting of *Ralstonia solanacearum*, *Sinorhizobium meliloti*,
20 *Homo sapiens*, *Mesorhizobium loti*, *Oryza sativa*, *Drosophila melanogaster*, *Rhizobium leguminosarum*, *Xylella fastidiosa*, *Deinococcus radiodurans*, *Achromobacter cycloclastes*, *Candida cylindracea*, *Streptomyces lavendulae*, *Streptococcus pneumoniae*, *Mycobacterium tuberculosis*, *Pseudomonas aeruginosa*, *Sus scrofa*, *Mycobacterium leprae*, *Streptomyces coelicolor*, *Pseudomonas sp.*, *Thauera aromatica*, *Brucella melitensis*, *Streptomyces noursei*, *Rhizobium meliloti*, *Synechococcus elongates*,
25 *Rhodobacter capsulatus*, *Agrobacterium tumefaciens*, *Mycobacterium smegmatis*, *Drosophila virilis*, *Mus musculus*, *Leishmania major*, *Botrytis cinerea*, *Caulobacter crescentus*, *Rhodobacter sphaeroides*, *Spermatozopsis similes*, *Giardia intestinalis*, *Triticum aestivum*, *Bovine herpesvirus*, *Streptomyces sp.*, *Streptomyces peucetius*,
30 *Rhizobium sp.*, *Haloferax volcanii*, *Streptomyces viridochromogenes*, *Felis catus*, *Xanthomonas campestris*, *Thermotoga maritime*, *Thermotoga neapolitana*, *Frankia alni*,

Halobacterium NRC-1, *Glycine max*, *Leishmania tarentolae*, *Neisseria meningitides*, *Escherichia coli*, *Caenorhabditis elegans*, *Leishmania mexicana*, *Zea mays*, *Ictalurid herpesvirus*, *Rattus norvegicus*, *Arabidopsis thaliana*, *Pseudomonas fluorescens*, *Pantoea agglomerans*, *Erwinia uredovora*, *Pantoea ananatis*, *Streptomyces hygroscopicus*,
 5 *Rickettsia typhi*, *Pseudomonas cruciviae*, *Xanthomonas albilineans*, *Halobacterium salinarium*, *Micromonospora griseorubida*, *Pseudomonas paucimobilis*, *Streptomyces lividans*, *Pyrobaculum aerophilum*, *Sinorhizobium meliloti*, *Mesorhizobium loti*, *Bacillus halodurans*, *Trypanosoma rangeli*, *Trypanosoma minasense*, *Trypanosoma leeuwenhoekii*, and *Brassica napus* using an appropriate third nucleic acid molecule.

10

40. An isolated polypeptide encoded by the nucleic acid of claim 39.

41. The isolated polypeptide of claim 40, wherein said polypeptide has an amino acid sequence selected from the group consisting of SEQ ID NOs:24-44 and SEQ
 15 ID NO:45.

42. A method for detecting the presence or absence of *M. paratuberculosis* in a biological sample, comprising the steps of:

contacting said biological sample with one or more nucleic acids
 20 comprising a nucleic acid molecule having a sequence selected from the group consisting of SEQ ID NOs:1-22 and SEQ ID NO:23 under standard amplification conditions, wherein an amplification product is produced if *M. paratuberculosis* nucleic acid is present in said biological sample; and

detecting the presence or absence of said amplification product,
 25 wherein the presence of said amplification product indicates the presence of *M. paratuberculosis* in the biological sample, and wherein the absence of said amplification product indicates the absence of *M. paratuberculosis* in the biological sample.

43. The method of claim 42, wherein said one or more nucleic acids comprise a sequence selected from the group consisting of SEQ ID NOs:46-100 and SEQ ID NO:101.

5 44. A method for detecting the presence or absence of *M. paratuberculosis* in a biological sample, comprising the steps of:
 contacting said biological sample with one or more nucleic acids comprising a nucleic acid molecule having a sequence selected from the group consisting of SEQ ID NOs:1-22 and SEQ ID NO:23 under hybridization conditions, wherein a
10 hybridization complex is produced if *M. paratuberculosis* nucleic acid molecules are present in said biological sample; and
 detecting the presence or absence of said hybridization complex, wherein the presence of said hybridization complex indicates the presence of *M. paratuberculosis* in said biological sample, and wherein the absence of said
15 hybridization complex indicates the absence of *M. paratuberculosis* in said biological sample.

 45. The method of claim 44, wherein said one or more nucleic acids comprise a sequence selected from the group consisting of SEQ ID NOs:46-100 and SEQ ID
20 NO:101.

 46. A method for detecting the presence or absence of *M. paratuberculosis* in a biological sample, comprising the steps of:
 contacting said biological sample with a polypeptide having an amino acid
25 sequence selected from the group consisting of SEQ ID NOs:24-44 and SEQ ID NO:45, wherein a polypeptide-antibody complex is produced if an antibody having specific binding affinity for said polypeptide is present in said sample; and
 detecting the presence or absence of said polypeptide-antibody complex, wherein the presence of said polypeptide-antibody complex indicates the
30 presence of *M. paratuberculosis* in said biological sample, and wherein the absence of

said polypeptide-antibody complex indicates the absence of *M. paratuberculosis* in said biological sample.

47. A method for detecting the presence or absence of *M. paratuberculosis* in
5 a biological sample, comprising the steps of:
contacting said biological sample with an antibody having specific binding
affinity for a polypeptide having an amino acid sequence selected from the group
consisting of SEQ ID NOs:24-44 and SEQ ID NO:45, wherein an antibody-polypeptide
complex is produced if a polypeptide is present in said biological sample for which said
10 antibody has specific binding affinity, and
detecting the presence or absence of said antibody-polypeptide complex,
wherein the presence of said antibody-polypeptide complex indicates the
presence of *M. paratuberculosis* in said biological sample, and wherein the absence of
said antibody-polypeptide complex indicates the absence of *M. paratuberculosis* in said
15 biological sample.

48. A method of preventing infection by *M. paratuberculosis* in an animal,
comprising the steps of:
administering a compound to said animal, wherein said compound
20 comprises a polypeptide having an amino acid sequence selected from the group
consisting of SEQ ID NOs:24-44 and SEQ ID NO:45,
wherein said compound immunizes said animal against *M.*
paratuberculosis.

- 25 49. A method of preventing infection by *M. paratuberculosis* in an animal,
comprising the steps of:
administering a compound to said animal, wherein said compound
comprises the nucleic acid of claim 39,
wherein said compound immunizes said animal against *M.*
30 *paratuberculosis*.

50. A composition comprising a first oligonucleotide primer and a second oligonucleotide primer, wherein said first oligonucleotide primer and said second oligonucleotide primer are each 10 to 50 nucleotides in length, and wherein said first and second oligonucleotide primers, in the presence of *M. paratuberculosis* nucleic acid, generate an amplification product under standard amplification conditions, but do not generate an amplification product in the presence of *M. avium* subsp. *avium* nucleic acid.

51. An isolated nucleic acid, wherein said nucleic acid comprises a nucleic acid molecule greater than 10 nucleotides in length, said molecule having at least 75% sequence identity to SEQ ID NO:1355 or to the complement of SEQ ID NO:1355, wherein said molecule hybridizes under stringent conditions with *M. paratuberculosis* nucleic acid but does not hybridize with *M. avium* subsp. *avium* nucleic acid under the same hybridization conditions.

52. An article of manufacture, wherein said article of manufacture comprises the composition of claim 50.

53. An article of manufacture, wherein said article of manufacture comprises the isolated nucleic acid of claim 1.

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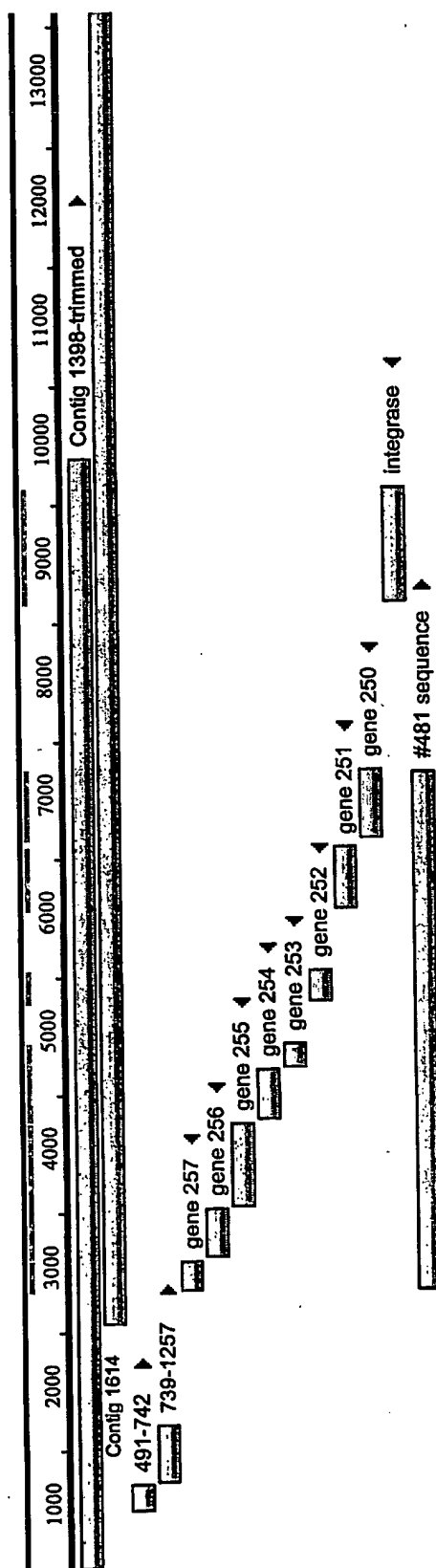


Figure 1

Gene 10 (SEQ ID NO:1)

GTGCGCCCGCACACCGCGGACGGCGGATCAGCATCTACTGGACGTGGAGCTATCCGTGGGAATCGCAGCGCGAC
ATTCAGACCCTGGACAACCGCTTCTCCACCATGACCGAAGTGCCGAGGGCGGCCTGGCCCCGATACGAGGGGGCCC
GACTGGGACGACGCCCCTTTCTGCAGGGCATCGCCGGCACCTTGGAGCTTTTCCACCGCTCGACGCTTGCGTTC
CAGGAGCTGGCCGGCGAAGCAACCGGTGACGAGGTGGCGGTGTTCCAGCGCGTCGACCAGGCGGGCTACCGGCTG
GTGATCGACGAGCGGATATTGGCCGACACCGACACCTGATGGTGTTCGGGCTGGACCATCTCGCCGGGGAAGAC
GAGGCCGAGCCCGGGGAGATCTCGGCCATCCGTGCCTGGCTGGAAACGCGAGGGCACCTGCCTGCTGCTGGCCCCG
CACCACGACGTGCGCGGCACCGACGACATGGCCAGCGGCAGGTGCAATACCTGCACCAGGGGATCCGCTCGTG
CCGCGGCAACAACGGTTTTCGCTACACCCGCTCGCTGATGAAGGGGCTCGACGTTCCCGTCCGCAACAGGTGG
GGCTGCTGACGATGTCACGACGCTGAACTTTACCCGCTGCTGACCTGCTTTTCGCGACCTGGACGCGCCC
GGGCTGCTGGACGATGTCACGACGCTGAACTTTACCCGCTGCTGCGCACTACGAGCTACCGCCCCGGAAGC
GACGGGCTACGGGTGCTGGCCACCCAACGCTGCGACCCGGCCCCGGCCCCATCCCTTTACCGAGGCGGGCAACAGC
GAATTCACGCGTTGATCTGGATGCCGCCGACGCCGAACGAGCCGGTGACATCGTGCTCGTTCGACTCGACCAAC
TTCACGACGCTGTTTCGGCGGGTCCGACAGCCTCAGAACTTCTGGCACAACCTGGCCACGATGAGGTGA

Gene 11 (SEQ ID NO:2)

ATGGTGGCAACCGAACACGAGTGGAGCAACCCGCGGCCCTGGCCATTCCAGGGAGGGCTACTTCGAGCTCGAA
CGCGGTGCTTACGGGGCGCTGTATCCCCGCACCCCGGCCTGCTACGGCTTTTCCATCATCGCCAAGGTCAAGGAG
GGCCGCGAGGAAGCCGTCCGCGCCTACGGCAACAGATCGAAGAGGCCATCAAGGCCGATCCGCACGTGCTTGCC
GCGTTCGCGGCTGCACTACCTGCGCTGGTTGCTTTCGACGTGCGATCGGGACTGCACTTCCAGTACAGGGGCATC
TTCGACACGGACTTCGACAAGTACACCGAGGACGCGGTGACGCTGTTTCAGTCAGACCGGGATCACCACCGTCTTC
ACGAACCTCGAGGGGTTTCCGAAGACTGGCGGGAGAACC CGGACGCTTCGTCAAGTTCGTGCGTGAGCACCAG
TGCCCCGAGCTTTCTGGAGTACGGGGAGTATCCCTACGTACCGCCGACGAGATCAAAAAGGCGTACGGCTCAAGC
CGCTCCCAGACCATGCTGGATCAGATGCAATGACGTGCGTCAGAGTCTGA

Gene 38 (SEQ ID NO:3)

ATGGTGGTAAGCATTTTCGGCTCCACGGTGCCGATACCCAGGCGATGACGTTACGCGGTCTGCGGTGAGACATC
GGACAGAAGCCGACGCGTGGGCAGCACCGTCAACGGGACGCCGCGATCTTCGAAC TGCCAGTTCGGCCCCATGAGA
GATGTAGGTCAATTCGACTTCTCCCGGCGCTTCGCTTCGGTGTCCGACCACCGGATGTCGACGACAGGTGCGT
GGCCTCGTAGGTGCGGTGACGATCCGACCAGTGCGGATCGACACCGGTGGCCATGACCTCGAGGGGACTGACATC
GTGCGTCGACAGCGTCGCCATCCAAC TGCGGTGCGGACGGCGGGGAGTTGCTTGGGATGCGCACCCCGCACCGC
GTGCGCGCTCCTGTCCCGAGGCGCTCCACGGATGCTCCGGTGTAGGCGAACGGGCGCAGGGCGGGATGCAATC
GAGGACCGAAGCAAGGTCACTGCGCCGACGCCAAACCCGAGGCTGCTTTGATGCGCGCGAACCGACGTAG

Gene 56 (SEQ ID NO:4)

ATGAACACTTCTTCTCTACCTGTGACACCTGGACGTACCCGACCCACCGGATGCCACTGAGGTTTACGGC
TGGGCAGCGCACCCAGACGGTCTGGCCGCCCCGTGCATTGCAAGCAGCGGTGCGTGACTGCGCCGGCTACCGGGTC
CGGGTGCGCGGTGCGCAACGCTCCAACGTACCTGCCGCGCTGGGTGGCCATCGAAGCCGACCCGGCGCCGAC
GAGCAAGCGTTGGAGCCCGAAGCGGTGCGGCAGCTGGCGCGCGAGATGAGCGTCACGCCCTACCACGCGCCGAC
GCTGAGATGCTCGACGACGCGCGCTTCGATGCGATCGTCGCGGTGTTTCAGTCAACGGGCCCCGATGCGAGATGCAA
ACGCTGTGCGGGAGGCAAGTGCCACGGGCTGCGCGCTGGCGCATGATTTGCACGGGTGCGAACAGGCCATTGTG
TGCGGGCAGCACAAAGAAAGCGTGGCTGCAGGAGGCCCTAGCCAACCTCTGGCGCGGCATTCAACCTCGCTGCGCC
CACTGCGGAAGAGTGTTCACAGCTTCCAAGACGCGGTGAGGATCACCGCATATGA

Gene 57 (SEQ ID NO:5)

ATGGCCACCAACGACGACCAAGACGACGGGAAGCCACCCATTACCGCGGCCGCTGGCGGTGATGAGACCGCGATC
GGGGCGGCCGCTGATGAAACCGAGCTCGTCGCGCCGCTCACCGTGCCCGCTCCGAGTTGGCTTGGTCCACGAG
GACAGCGACGCTGGTGATTACTCGTGCGGCCGGGCTGCGGAACGCGCCAGCATCATCGTGCTGCGCTGTGCGGCG
GTCGCTGTGCTGATCGGTTTGTGACCTGGCTCGCTTGACCTACACGACGAGGCCAAGCCGACAGCGGCCCG
ACGGCCGCGCG

Gene 128 (SEQ ID NO:6)

ATGAGCGCCAGGGATCTCATCAACATCGGGGTCTTCGGCGCTCTCTACATCGCCACTGTGTTGCGGATCAACGTG
TTCGCTTTCATCAATCCGCTCGTCATGTTGGTCGCCCTGGCGGTGACGATGATCGCCGGCGGGCTGCCGTTTCATG
TTGTTCTTACCCGGGTGCGACATGCGGGCATGGTGACGGTGTTCGCGATTATCACGGCCGGACTGCTCGCACTG
ACCGGGCACCCCCGATCTGCTTCGTGATCAGTTGCGTGCGCGTTGGTGGCCGAAGTCGTCCTGTGGCTGGGA
CGCTATCGCTCCCGCACCATGGGTGTACTGGCGTACGCAATCTACGCGCGGTGGTACATCGGGCCGCTGCTGCC
ATCTTCTACGCTCGCGATGAATATTTCTCCAGTCCCGCATGGCACAGATGGGTCCGCGCTACCTCGAAGAGATG

Figure 2-1

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GAACGGTTGTTGTCGCCAGCCGTGCTAATCGCATTTCGACCTGTCCACGGTGGTATTCTGGGCTGATCGGCGGACTG
CTCGGAGTAAGGTTGCTGCGCAAGCATTTTCAGAGGGCCGGCCTAGCTTGA

Gene 135 (SEQ ID NO:7)

ATGGCGGGGATGCCGAGGAGGTGCTGCGCTTCTGCGCGGTTTCCACGCATCGGCGCGCGGAGCAGGCGTTT
GCGTTCTTGACCGTTGACACTGGCGGGTTTCCACATGCGGCGTTGCTGTGCGGCTGCGAGCTCGAGCCTGGGCGG
GACCCCCAAACACTGATGGCCGCCATAGCTAGCCGACAGACCCGCGCCAATTGCGGCGTAGCGGCACCGCGGGG
CTGCTCGCAATCAATGGCACTAGTTGCCACCACCTCAAGCTGCGAGTGGTGCCTCGCTCGGTGCGGGAATA
CTCGGATGTGTGTTTGCCGTGACCGAACATAAGCGCGATGACATGGGAATACCCTTGACGCTACGCTATTTTCGG
ACCTCGGCCGAGATCTCGGTGCTTGAGGACTGGCCGCGTAGTCGGGCCATGTTTCGACCGTCTCGCAGCGCTGCGC
AGCGCAGCGCGGGAGGTCTTATGA

Gene 159 (SEQ ID NO:8)

ATGCGTTTCGCCCTCCCGACGCGCATCCTGCACTGGCTGATGGCGCCGATGGTCATCGGGCAGCTGCTCATCGGG
GTGGTCATGATCAGTCGTTGACCTACTATCCGCTGCTGCTGGCCATCCACCGGCCGTTGGGCGCCTTGATCCTG
GCGTTTGCGGTGGTGCCTGGCGAACCGGTTACCCACCGGCTGCCGCCCTTCTTGCCACGATGGGCCCCGTC
GAACGCGCGCTGCGGACATGGTGGAGTACCTGCTCTATGCCCTGCTGCTAGCCAGCCCTTGATCGGGTGGGCG
ATGCTGTGCGGCGCGCGGTTCCCGGTGCTTGGTGGGACCGTGCATCTGCCCGGCATCGCACCGCACAACGTC
GACGTCTATGCGGCGCTGCGCCAAGCCACAACGTCGGCGCCTTCTGCTTTTCTGACCTTACGGCCCCACGTC
TGCGCGGTCTCTTTTATACGCTCGGCCTGCGCGACCGGCTCCTCGATCGCATGGCGCTGTGGCCCAACAAGCCC
GTGCTCGCGGCAGGACGAAATCAAGCGTGA

Gene 217 (SEQ ID NO:9)

CTGCGCAGGCTGATGGCCGAACGCGGACTGTTCAACACGACAGCGTTGCGGCCACTGCTGGCCGAACGCGGGGTG
CAGCTGTGCGCCAGGCTACCGGCTCGTGACCGAGAAACCGGAACGGTTGAGCCTGCCACCCTGGTGGCA
CTGGTGGACATTTTGAGGTGTGCGATGGACGAGTTGATCGAGATCGTCCCCGCCACAGCTGCCTCGGCGAAGAAG
GCCGCGGGCGCACCGGAGCGCAGCAAACCGGTGAGGACGCGGGAAGTTGGTGGCCACCGCCCCGTCCGGGCCAAG
ATCGTCGACGCGGATTCTAG

Gene 218 (SEQ ID NO:10)

ATGCGCGGAAACCGCAGCGAGTTCGTGACGGTGATCGTCACTGCACTGGGCGCGATCGAGCCGCACCTGAGCCAC
GACGATGTCCGCACCGCGATCGAGGGGATGGGCCTGTGCGCCGCGCAGTTGCAGAGGCTGTCTAGAACGCTGCGG
CGCGACGGTAGCGTGCTACCGGGCCCGCGGCGAGCGACTGCGCCGCGGACATCGAGCAGCTGATCCTGTGTCTG
CGCTAATCGGCGCCATGCGTGTTGAGCGCGCGGTGTGCCAGTGCGGCCGCAACGATTCCGAAACCTACTCG
CGCAAGCTCAAGAAGCGCATCTGCCGAGCCTGTTGATGACAGGGTTGGCAGCCGGCTGTGCGGTGAATGCCGGGC
TGCGGCGCGGTGGACAAGTTGATCTACCGGCCGCGGCACGGCGATGGCCTGTTGTGTGCGAGGTGCAAGCCCGAA
CCCCGACGTGATCAGCGCCCAAGGTTGCTGACGGTATCGCGCAACTGCGGACCGGGCTTTGCGCCACCGAGATT
GACCGGGTGGCGTGGTGTTGCGGCACGGCGGTGCGCGACGCGGAGCTTAACGGATCTTGACAGGACACCCCGGA
GTGTTTCGCGGTGAGATCGCCACCGCTCGGCGGTCTCGGTGCGGCTCGCCGAACTACTTGTGCTGCGCGGTGCC
GACAATGTGCGCCTCCGAGTGCCCGTTGTGTTTGCACACCGTGAAGCTCGGCAGCCAGATTGACGGGTGCGC
TGCTGCCATACCTGTGGGTACCACTTACCGCGCGGACCTGCGCTCGTTGCGGTGCCAGCGTCACCTTATC
AATTATCACGGTGCCGCGAGCGCCTCTGTACCGTTGTTTCGAGCATGATCCGGTCAATCATGAGCCGTGTACA
CGGTGCGGTGCTGTGGAATTCATCAACCACCATGACGGCCAAGCGAAGCTCTGCCGCGCTGCTACCCGGCACCC
ACCGCGGTCTGCAGCTCGTGCAGGCTACTCGCCCATGCACCCGACCCGACGGGAAGCCGATCTGCGGCACC
TGCTCGGCCAAACAGCGCCACCCCAACCTGTTGCGGTATGCGGCAACATCCGCTCCGTGCACACCCGGACTGAC
GCCGGTGAGCCGGTGTAACCCGTGCGCACGAAGTCGGGAACCGTGCGCGCGGTGCGGCAAAACGCTGGGGGT
TCGGCGCGGCTTGCCGGGGTTCGGGCGCTGTGCTCGGCTGCTGCAACGTGAACCCGCTATTTACCCGACTGT
GTGCAATGCGGCGCCCATGGACGGAGTACCACCGTGGGCTGTGCCGCGCTGCGCCTGTCCCGGTGAGCTCCGC
ATGCCGGTGCTGCGATGGGTGACGCGATGCGATCGAACAGTGAAGTGCAGCGAGCTGCGGCAACTCGGCGAC
ACCTCAGCCACCACGACCTCGATGACCTCCCGGCCAGCAAATCCGTGGAATGGCTTCGCAACATCCTGGTGACC
GCCGAGGGTCTGCCAGACCGGACCCCTATCTGCACCGCACCGAGTACATCGCCGCGCGGTGGCCACCATC
AGCAACCGCGACGATCGCGCGGCGCTCCGCGCATTCACCGAATGGAATCATTTGCGTAACTCCGGGCGCGGCC
GACAAAGGACCACTCAAACGCAACCACGGCTCGCCGCGGAGATCATGGCCGCGCCATCACCGACTTCGTCTCC
GAACTCAACGCGCACGGACTGGCCTTGGCCTCATGCCAGCAGGCGTTCGTGACGACTGGTTGGTGCAGCAACCC
ACTCGCCGCGAGATCCACCAATTCCTCGCTGGGCGGTCCACCGTGGCTACGCCACGACGTCGCGGCTCCCGTA
CCGCAAAACCCGCGCACCCGCCACCCCTGCCGCGGACGACGAACGATGGCGCCTGATCCAATACCTGATCGAA
CACCCGACTTGAGAGCGCGCATCGGGTGCCTGGGCTGCTCGTGCTCTACAGCAACCCGCGCGCGCTG

Figure 2-2

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GTCACCCCTCAAGGTTGCCGACGTACCCATCACCGACGACGCGGTCCAACCTCACCCCTGGCGCCGTCCCGCTCACC
GTGCCCAGCCCCGTGACCGCCTGCTCGCCGATCTCGTACAGCAGCGCCGCGGATAC6CCGCGGTACCCGTGGGC
ACCAATCCATGGCTGTTTCCCGGAGGACGCTCCGGTGGGCACCTGTCCGCCAACCAAGTGGGGCTGCGGCTCAAA
CGAATTGGCATCTCCCCCGGATCGCCGCAACACCGCGCTGATCGACCTCGCCGGCGAACTGCCCCGTGTCGTG
CTCGCCAAACTCCTCGGCTTACGATCAAACGCGCCGTACCTGGAGCGAAGAAGCCGGCAACACTCGCCCCCGC
TACGCCGCCGAGGTGCCCCGCCCAACTCGTGA

Gene 219 (SEQ ID NO:11)

GTGTCAACATCTACTGAGCGCCGTTTTCGCTTACAGGTGCGCGTTACGAGAGCTGGGCGCGCACCGAAAACCGT
TCCGCGCGAACGCATAACGCCCCGTAAGGCGGCATGGGACCGCTTCGAAAAGCAGGTGATCCCGAGGGCAAGCTA
CCCCCGCCCTGCGCGCCAAGATGGCCGAGAACGCGCGCGGCCCACTTCAAGAAGATGGCGTTGAAGTCCGTC
GAGTCCCGGCGCGCTCGCCGGGACGGGGTGGCGGCGTGA

Gene 228 (SEQ ID NO:12)

GTGCCATACGCCGAATCGCCAGGACCCGCACCGGGGGTGTGTTACCCCTCGAGCAGGCTCAGCCCGACGACGGC
CTCGTGGTTGTCCGCGCCGTGGCCTTGGTCAACGCGCAATCGGTGATGATTCCGGTGTGCGGCTCGACGGCAAG
GTGGGCTTTGAAGCCGTCTGGCGGCGGTGCACCGTCTTGTGAGCGTGCCGCGTGTGCGCATCGACGGTGGAGAT
CACGCGATCCCCACTGACCTGCTGCGCGATGCGCCAGTGGCCGTGCGGTGCCATCAGAGCCCTCGACCGGTTCAAC
GTCTTGACCGGCGATCAACGCCAACACGCCACCGCCTCAGCAGCCCGCGGCGGAGTTCCTGGTCAGGCAGATA
GCCCAGCACCCGGTGAGCATCACCGACCAACCATCCACCAGCCGATCCCGAGCGGCCTTATCCTCCCACGCAAT
CGCGGGTTTCCCGGATCGTCGTAATCATGGGCGCTGCAGTGGGCTTCGATCACCGCTGCAGCGCCAGGGACTTC
GCGGCGCACTCGTCGGATCGCGGCGATCAACTGCGTCACGGTGTCTGCGTGGCCACCGCATCGTCGAGCACCGT
GGAATCCAAGGCCCGCGTGTCTTGCCCGCCAACACCCCGTCTCGGCCACCACCGTCTTGACCGCCTCGAAGAT
CCGGTTGGGCGGATCCGAAGCCGCCAACCGACGCGGCCAATACGTCAACGTGTCGAATGAAACGCGCCCGCGT
GATCGGCAACCCGCACGCTGCTTCCAGCGCAGATCGAAAGTACCGCATCCACGGTCTCGTTATCCGAAAAACC
GTGAGGGCCTGCAAGGTGATCACCGAGGCCATCACCTCAGCCGGCACGCTGGGCGGCCCCGCTGCGACGGGAA
CAAGTCCGCGAACATCTCCTCGGGAAACAACTGGCTGCGGTGCGCCGCCAGGAACGCAACATGCTGTGCGCCTT
CAGAAGATGCCCCGCAACCGACTCCGCATCCAACAACACGCTGATCATCAGAGCGACCTGCACCCAAACAATC
ATCCCCAAAACCCAGGACAACCTCGTCCCGCCACGCGGAATTAATTACGAGGCTCCTAG

Gene 240 (SEQ ID NO:13)

TTGGTCATTGCGCTAGCTGCCTTGTGGAGCATCCGTTTGGCCTGGCACATCCCGTTTCGAGCGAGCAGCAGTGTG
GCACTGGCGTTTATGTGTGCCAGTTGGTCTGGCGCTCGGGCCGGTGGACGGGTGGCTGAGCCCATTTGCTCCAC
GACATGACGGGCGTGTGGAACCTCGAAGACCTCATCGGCCATCTGCTCTACGTGTACGGCTTGTCTCGATCATG
TATCTGGTCGCTGACCACTGCGACATGACGCCGGGTGAGCTCAGGTGGTTCGTTCCGAACCGGTTGGAATGCCG
TCGGTCTGTGATCTGCCCGTCATGATCGCGGTCTTCGTGCGAGGCGACATCGGCGAGACCTGTGTTCCCGATGTT
GTGGCCACAGAACACACGCCCTGGCTCCGCGTCTACTGGTTCGTAATGATCGCGGCTCTTGCGTACATCATTTGTC
TCTACCGGTGCAATCCTGTTGATCCTGAGGACGACCCACGCTCGAGGCATGCCGCCACGGCCTATCTCGTAGCG
CTCGGTATCACTGGCGCGTGTGCTGCGTGGTTTTCATCATCGGAATCCCTTGGCTGCAATGCGCTTCTCGTGGGTG
GAGGTAGTCGGCTATGCGGTGGCCGCTCGTACTCCTGGCGTAACAAAGTGGCTTACTTTCTGTTGACGCTAG

Gene 241 (SEQ ID NO:14)

TTGCACGAAATCCTCCGGTTTGGCGGGAAAACCGACGAATTGATCGGTTTTGCCGCGCTTTGTGCGTTTCAGACT
GCTACCCCTGCCGGGATGTCTTCGCATTTCGCTGTGTGCGGCCGCCCTGGCCAGCCGATTGCGGATGATCATG
GGCGACCGCAAGCTGTCCCGTACCCGTCTTCTCAGAGACAGGTATCAGCCGCCGAGCCTTTCTAGCAAGCTC
GATGGCAAGGTCGAGTTCACCTACAGTGAGCTACTTACGATCGCCAGGCGGTGATGTTCCGCTGGACAAGCTG
CTCGCCGGAGACGACGATGAGCGGCCCTTCCGCCTGAGTGACTTGAGACCTCGACCCGATCGACCTCTGTGA

Gene 250 (SEQ ID NO:15)

ATGGTTGCGGCGCAAGGCTCCTCGATGCTAACCGCTGCCGATTTCCGCCGCGCAATGGGCCGATGTTCCCCCGTGG
GAACCGCCCGACGAACACCGCAGCGAAACGGCCAACGACAGCAGGCAAGCGCCGAGCCGACCACGTGGGAG
GCGTTCGATCTCGGACCTACCTGCGCGCGGAAATCGAACGCCACATCCCGGTATCGGCATATCACGCTCCGAC
GGGACGCGGTGCTCTACCTGGTTCGCGAGCACGCCATAGTCGGTGAAACCGAAAGCGGTAAAACCTGGTTTCGCG
TTGGGCTGCGCCGCGCAGAACTCAACGCCGGCAACGACGTCGTGTATATCCACTACGAAGAACCCGACGCGACG
AGCACCGTCGAGAAGCTGTGCTTGGTTCGACCCCGGTGATCAAGGCCGCTTTCGTTTCGTGCTGCTGCC
AGCCGCCCCGTCCGTGAGGAGTGGCTGAACGCACTACTTGACCCCTTACCGACGCTGGTTCATCCACGACGCGTC
AACGAAGCGATGGCGCTGCACGGCGACGAGATCAAGGCCGTGAGGGCGCCGCGGGCGTTTCGCCGGCCGACTGA

Figure 2-3

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Gene 251 (SEQ ID NO:16)

ATGGTGC GCGACGGCAGCCGCGGATGCCTACGGTTTCGGTGCATAAGGGCAACGCGCTCGACGGGGCTCGGTTT
GTGCTCGAGAACTCGGCGCCGTTTCGGCCGGCGGCTGCGCGGCGTCTCCTACGTCTTCGTGACCAAAGACCGCCCC
GGGCATCTACGGGCCAACGGGCGCGCAACGAAGTCGCCCCGGAAGACGTTTCATGGGAACCTCTGGTTCGTGATGAC
TCGACAGGCGTTTCGGTCTGACTTCACGATGCGGTTCTTCGCGCCAGGGACGACGACGTGCCTGAGAGCGATCCG
AACGCCGAGCTGGCTGACGCTGTCTTTCGCGTCGTTGCTGCGGCTCCCGACACGCTGTTGGGTCGATGCGGCTG
TTGTTTCGTGAGTTACGCAACGTCGACATCCAGTTCCGTGACGACGATGTGCGCGACGTGCTCGATGACCTTGTG
GTGTCAGGCCGCTCTCGTAGAGATATCAGGCAAGCGTGCGCCAAAGGGGTTTCAGGGCCGTTGTGGAGGACGCCGAT
GGGACAGCACGTGA

Gene 252 (SEQ ID NO:17)

ATGACCACCGACAACCCACGCCCTCTGATGACCAGGCACTGGCCGCCCTCTACGCCACAGCACTCGGCGTGCTC
CTGGCCGGCCTCGTCAACGACGACGCTCAGACCGAGATCGAGCGCATCATCGCCGCCGGCGAGAAAGTCACC
GCCGGCGTCTCGGCTTCCTGACCGCAGCAGCCGCCAACGCCTACGAATACGAGCAGGCGAGCCGAGAAGCCGCC
ATCGACGCGATCACCGCAGACCTGGCCACCGTGCTGCTCGCCGCCGGAGAGGGACAGCCCTCATGA

Gene 253 (SEQ ID NO:18)

TTGACCGCGTTGACGGCGTTGCGCGACGTCTGGCGGCGGCGATCGATGAATGCGGGTCGAAACGTGATTTGGCC
GCGTTGTTGCGGCAGTTACCGCTGTCTGGCGCAGATCGAGGCGGCGGGGTACGGCCACCGCAACGTGCGATT
GCCGATGAGATTGCGGCCCGGCGACAGCTCGGCAGCCGCGGCCGCTGCCGATGCGAAGAGCGCGGACCGCTGA

Gene 254 (SEQ ID NO:19)

ATGAGCGACGAGTTACGCCAGCGCTACAAGGTGATTTTCGATGCAGTCCGGGTGAGCGAAATCGAGATCACCCCG
GACTTTGCGCGGTGCCTCGTGCCTGGCTGATTACATCCGGCTCAAGCAGCAGCCTGGGCAGCCCGGTGTC
CCGAGGGGTTAGTTGCGGCGCAGACGGCGCTTGCCGAGGCGTACGCCGCGGTTACTCACTCGCTCGAAGCGAG
CGGGATCGCCCGATCGGGGCTGGATTTCGTATTCTCAGCCCATGACGCGTGGGTGGGCACTGCGGAAGCCGCTGAG
ATGCTCGGGATCAAGGCGGGCAGCGTCGGTTGGCTTTGCCGGGAGAGTCATCTTGAGCACCGGAAAGTTGGCCGG
CAGTACATGATTTGACCCGATCGATCGAGGACTACAAACGCCGCAAGGCTGAAAGGAGCGCGTGA

Gene 255 (SEQ ID NO:20)

ATGGTCAACGTGCCGCGTGCGGAACCTGCGCGGCTGGTGGGGGTTTCGCCGACGTGACGATCTAACGTTGCAG
CAGGCCATCGATTCCAAGCTCGCGCAGAAATGAGGCCGAAAAGCACGCTCACGCGGTGTCTGCGGCCGAGCAGCGG
GACCGCGCGGATGACCGGCGAATCGTCATCGCTGCCTACAACGAAGGCCGATTCCGCGAGAGCCGCATCGACTTC
TGGTGCAGAGCAATGCAACGAGACCGCGCCGGAACAGGGCTATCCTCGCGGCTTTGGCGCCGGGACTGGCCCCG
CCTGAAAAGCTCCCTACTGACCCGCGATCGAACATGTCCACGCGAAAGTCTTGCTCGGATGGGCATCCGGCCG
CCGGCATCTGCTCCACATCGCAGACTGTGCTGCGTCATCGCCACCGCCGTCACCGAGGCGTCGATGATTTGGGC
ATACCGATCGCGCCGTTGCGGCCACCTGTGCGCATCGTGCGCATCGTGACGGCAAAGATCCGGCCACGTGGTCC
AAAGAAGAGCGCGATAACCGCTGCTGTACGGGCTCGGCCCCCGGTTCCGCCGAGCGGCGGCGCGCTGGGATC
CCACGCCACCCGAGGCTCCGGGTACTACCAGCCGACCGGCATCGAGCCCTACGAGCCCGTCGACCTGGGTGGC
GGTCAGATCGAGTGGCGCGCCAAGCCGACTACCGGCCGCGGGGTGACTGA

Gene 256 (SEQ ID NO:21)

ATGGCATAACGAATGAGTCCCCGCGTCGAGATGCTGGCCGTCAAGGACCAGAACGGGATCATTTGGCATCACTAC
CAAAGACCTGTGCGGGGTGCCCCGAACCTTGGTCCGATCATTTGCGTGGATTGGCCCTGACTACCGGGATCGCTGG
CTACGCATGGGCCCTCATCGAGGAGATCCCCGACGACGCCGCGGCCGCCCTGTACAGCCCCCGCCAGCGATGCA
GTCGCCGGCCCCAATACCGATCTCGTCGACGAGTGCATCGCCGCGCTCGACCGTTTCGATGTGCCAGCCGATGCC
GGCGCCCCGACCGCGCGGAAAGCCCTGCGCGACAGGGGGCAAGCCTGGGGCAACGAGACCATCGCTGCTGCTGTC
CGCGCGCGCAAGGCCCGTGC CGCGCCGTCCGGGACGCCGGCAGGGTCATGA

Gene 257 (SEQ ID NO:22)

ATGAGCACACGACGGTGCCAGTCCGCGACGACCCGCTGCGATCACAGGGATTCCGCCGACGTGCACTCGGTTG
CAAGTCTCAACTCCAGCGAGGGGCTCGGTGATGCCGCCGGCGTCGACATCGTCGTCAACAACTCCGGAGGCTGT
TCGCTGGACCCGACAGCGGGATCCGGCTCAAAACCGGCGAGTTCTTCGTGTTCTCGCTACGCCAGCCACATGGG
GGCCCGGCCGNTTGCCGCTGTACGCGGTGCGGCGCGGCCCTGGTGGTCAGTTGA

#481 (SEQ ID NO:23)

TCAACTGACCACAGGGCGCGCGACCGGTACAGCGGCAANCGCCGGGCCCCCATGTGGCTGGCGTAGCGA
GAACACGAAGAACTCGCCGGGTTTGAGCCGATCCCCGTCTCGGGGTCCAGCGAACAGCCTCCGGAGTTGTTGAC

Figure 2-4

Figure 2-5

Gene 10 (SEQ ID NO:24)

VRPHGTGRRISYWTWSYPWESQRDIQTLDNRFSTMTEVRRAAWPRYEGPDWDDAHFLQGIAGTLELEFHRSTLAF
QELAGEATGQQVAVFORVDQAGYRLVIDERILADTDLMVFGLDHLAGEDEAEFGEISAIRAWLERECTCLLLAP
HHDVGGTDDMAQRQVEYLHHGDPLVPRQORFSAYTRSLMKGLDVPVRNRWGLHPARVAATGQMAPLTCFRDLDAF
GLLDDVTTLNHFHPLPHYELTAPESDGLRVLATQVRDPARPHPFTEAGNSEFNALIWMPPHAERAGDIVLVDSTN
FTTLFGGSDSLRNFHNLATMR*

Gene 11 (SEQ ID NO:25)

MVATEHEWSKPAALAIPEGYFELERGRYGLYPRTACYGFSIIAKVKEGREEAVRAYGKQIEEAIKADPHVLA
ALRLHYLRWLLFDVGSGLHFQYQGFIDTDFDKYTEDAVQLFSQTGITTVFTNLEGFPEDWRENPDFAVKEVREHQ
CPSFLEYGEYPYVTADEIKKAYGSSRLPDHAGSDAMTSVRV*

Gene 38 (SEQ ID NO:26)

MVVSISAPTVPPIQAMTFSGLRSDIGQKPTRGQHRQRDAAFELPVRPMRDVGHDFLPAIRFGVRPDPVDDQVA
GLVGRVQIRPVRIDTGGHDLEGTDIVRRQRRHPTAVADGGGVAWDAHPHRVARSCPEALHGCSGVGERAQGMQI
EDRSKVICADAKPEALMRAEPT*

Gene 56 (SEQ ID NO:27)

MNTSSSLPVDTLDTAPDATEVYGWAHPDGLAARAFEAAVRDCAGYRVRVRGAQRSNVTCRRWVAIEAAPGAD
EQALEPEAVRQLAPQMSVTPTTRRTAEMLDAAFDAIVAVFSQARCEMQTLSSGKCPRAARWRIDLHGCEQAI
CGQHKKAWLQEAALANLWRGIQPRCAHCGRVFNSEFQDAVRITAI*

Gene 57 (SEQ ID NO:28)

MATNDDQDDGKPPITAAAGGDETAIGAAADETELVAPLTVPASELAWSHEDSDAGDYSWGAAERASIIVLACAA
VAVVIGLLTWLALHLHDQAKPTAGPTAA

Gene 128 (SEQ ID NO:29)

MSARDLINIGVFGALYIATVFAINVFVAFINPLVMLVALAVSMIAGGVFEMFLTRVRHAGMVTVFIIITAGLLAL
TGHPPICFVITVACALVAEVVLWLGRYRSRTMGVLAYAIYAAYYIGPLLPIFYARDEYFSSPGMAQMGPYLEEM
ERLLSPAVLIAFDLSTVVFGLLIGLLGVRLLRKHFORAGLA*

Gene 135 (SEQ ID NO:30)

MAGMPEEVAALLRGFPRIAREQAFALFTVDTGGFPHAALLSRCELEPGRDPQTLMAAIASRQTRANLRRSGTAG
LLAINGTSCHLKLRVVASLVGRGILGCVFAVTEHKRDDMGIPLOPTLFRTSAEISVLEDWPRSRAMFDRLLAALR
SAAREVL*

Gene 159 (SEQ ID NO:31)

MRFALPTRILHWLAPMVIGQLLIGVVMITSLTYYPPLLAHRLPLGALILAFVVRLANRFTHRLPPFLATMGPV
ERRVATWSEYLLYALLAQPLIGWAMLSAARFPVVLVGPVHPLGIAPHNVDVYAALRQAHNVGAFLLFLTFTAHV
CAVLFTLGLRDRLDRMALWPTKPVASRQDEIKA*

Gene 217 (SEQ ID NO:32)

LRRLMAERGLFNTTALRPLLAERGVQLSASQVYRLVTEKPERLSLPTLVALVDILRCAMDELIEIVPATAASAKK
AAGAPERSKPVRTRELGGHRPVRAKIVDADS*

Gene 218 (SEQ ID NO:33)

MRGNRSEFVTIVTAVGAIEPHLSHDDVRTAIEGMGLSAAQLQRLSRTLRRDGSVLTGPGGSDCAADIEQLILCL
RQLGAMRVRAPRCAQCGRNDSETYSRKLKKRICRACSMQGWQPAVGECPCGAVDKLIYRPHGDGLLCRRCKPE
PDVDHAAKVRDGIQLRTGLSATEIDRVASVEGTAVAQRELNWILQDTPGVFRGEIAHRSVSVRLAELLVAAGA
DNVRLPQCPLCLRTVKLGSQIDGLRCCHTCWGHHSRGTCARCGCQRHLINHYGAGERLCHRCFEHDPVNHEPCT
RCGRVDFINHHGQAKLCRRCPAPTAVCSSCGRTRPCTRTTRTGKPICGTCSAKRPPQPCSVCGNIRSVHTRTD
AGEPVCNFCARSREPCARCGKTLGV SARLAGVGPLCSACLQREPAYFTDCVQCGAHGRTYHRGLCPACACPGELR
ELFAKNGELSGAASRIVEALLQCDAMPVLRWVRMRNSNELPAQLAELGDTLSHHDLDLPASKSVEWLRNIIVT
AEGLPDRDPYLHRTEQYIAARLATISNRDDRAAVRAFTENHRLRLRARADKGPLKRNHGLAAQIMAAAITDFVS
ELNAHGLALASCQQAFFVDDWLVRNPTRRQIHQFLAWAVHRGYAHDVAAPVPQTRRTRHTLPGDDEWRRLIQYLIE
HPDLETRDRVAGLLVLLYSQPAARLVTLKVADVTITDDAVQLTLGAVPLTVPSVPDRLLADLVQORRGYAAVTVG
TNPWLFPGGRSGGHLNANQVGLRLKRIGISPRIARNTALIDLAGELPVAVVLAKLLGFSIKRAVTWSEEAGNTRPR
YAAEVARRNS*

Figure 3-1

Gene 219 (SEQ ID NO:34)
VSTSTERRRLRLQVAVHESWARTENRSARTHNAKAAWDRFEKQVDPEGKLPALRAKMAENARAAHFKKMALKSV
ESRRRRRDGVAA*

Gene 228 (SEQ ID NO:35)
VPYAESPRTRTGGVFTLEQAQPDGGLVVVRAAGLGQRAIGDDSGVGLDGKVGFEAVLAAVHRLVSVPRVGIDGGD
HAIPTDLLRDAPVPVGAIRALDRFNVLTDGQRQQRHRLSSPRREFLVRLQIAQHVPVSITDQTIHQPIPSGLILPRN
RGFPRIIVIMGAAVGFDRHCSARDFAAHSSDRGDQLRHGVLGRHRIVEHRGIQGPCLARQHPLGHRLDRLED
FVGPIRSRQPTPIPIRQRRMKRARRDRQPARCFPAQIESHRIHGLVIRKTVQGLQGDHRGHLSRHAGPAPLRRE
QVREHLLGKQLAAVRRQERKHAVGLQKMPGNRLRIQQLTLIIRATLHPTIIPKTPGQLVPPRGINSAGS*

Gene 240 (SEQ ID NO:36)
LVIALAALWSIRLAWHIPFERAAVLALAFMCAQLVLALGPVDGWLSPLLHDMTGWNLEDLIGHLLYVYGLFSIM
YLVDHCDMTPGQLRWVFRNRLELPSVVICAVMIAVFVAGDIGETCVPDVVATEHTPWLRVYWFVMI AALAYIIV
STGRILLILRQHPRSRHAATAYLVALGITGACCVVFIIGIPWLQWLLVRCEVVGVAASYSWRNKVAYFRGR*

Gene 241 (SEQ ID NO:37)
LHEILRFGGKTDELIGFARALSVQTATLPGMSSHSPVSAAALASRLRMIMGDRKLSRTRLSHETGISRPSLSKSL
DGKVEFTYSELLTIAQAVDVPLDKLLAGDDDERPFLRSLDRPRDRPL*

Gene 250 (SEQ ID NO:38)
MVAAQGSSMLTAADFAAQWADVPPWEPPDEPPQRNQORQQQASAEPTTWEAFDLGPYLARGEIERPHPGIGISRSD
GQRSLYPGREHAIVGETESGKTWFALGCAAELNAGNDVVYIHYEEP DATSTVEKLCLLGVDP AVIKARFRFVAP
SRPVREEWLNALLDPSPTLVIHDGVNEAMALHGDEIKAVEGAAGVSPAD*

Gene 251 (SEQ ID NO:39)
MVRDGSRRDAYGSVHKGNALD GARFVLENSAPFGRRRLRGVS YVFVTKDRPGHLRANGRATKSPGKTFMGTLVDD
SQAFGPDEFTMRFFAPRDDVPESDPNAELADAVFRVVAAPDHAVGSMRLLEAELRNVDIQFRDDDV RDVDDLV
VSGRLVEISGKRGAKGFRAVVEDADGDST*

Gene 252 (SEQ ID NO:40)
MTDNPTPSDDQALAAALYATAGVLLAGLVNDGRLTTEIERIIAAGEKVTAGVLGFLTAAAANAYEYEHGSREAA
IDAVTADLATVLLAAGEGQPS*

Gene 253 (SEQ ID NO:41)
LTALTALRDVLAAAIDECCKSRDLAALLRQFTAVLAQIEAARVRPPQRRIDEIAARRTARQAAAAADAKSADR*

Gene 254 (SEQ ID NO:42)
MSDELRLQRYKVI FDAVRVSEIEITPDLARCLVHWLGDIYIRLKQQPGQPGVPEGLVAAQTALAEAYA AVTHSPRSE
RDRPIGAGFVFSAHDAWVGTAEEAEMLGIKAGSVGWL CRESHLEHRKVGRQYMISTASIEDYKRRKAERSA*

Gene 255 (SEQ ID NO:43)
MVNVPRAELARLVGVSPDVDDLTLQQAIDSKLAQNEAEKHAHAVSAAEQRARADRRIVIAAYNEGRIPQSRIDF
WCEAMQRDRAGNRAILAAAPGLAPPEKLPDTPQIEHVHAKVLARMGIRPPASAPTSQTVAASSPPP
SPGVDDLGIPIAPLPPPVRIVRHGKDPATWSKEERDNALLYGLGPRFAAAAAARGIPRPPGGSGYYQPTGIEP
YEPVDLGGGQIEWRAKPDYRPRGD*

Gene 256 (SEQ ID NO:44)
MAYRMSPRVEMLAVKDQNGIIWHHYQRPVGGARNLGP IIAWIGPDYDRWLRLMGLIEEIPDDAAAALSQPPPSDA
VAGPNTDLVDECIAALDRFDVPADAGAPTARKALDRDQAWGNETIAAAVRARKARAAPSGTPAGS*

Gene 257 (SEQ ID NO:45)
MSTTTVPVGTTPAAITGIPPDVDSVQVLNSSEGLGDAAGVDIVVNSSGGCSLDPQTGIRLKPGEFFVFSLRQPHG
GPAXCRCTRSR PALVVS*

Figure 3-2

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Gene 10 (SEQ ID NO:1)

GTGCGCCCGCACACCGCGGACGGCGGATCAGCATCTACTGGACGTGGAGCTATCCGTGGGAATCGCAGCGCGAC
ATTGAGACCTGGACAACCGCTTCTCCACCATGACCGAAGTGGCAGGGCGGCCTGGCCCCGATACGAGGGGGCC
GACTGGGACGACGCCCACTTCTGACGGGCATCGCCGGCACCTTGGAGCTTTTCCACCGCTCGACGCTTGCCTTC
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GAGGCCGAGCCCCGGGGAGATCTCGGCCATCCGTGCTGGCTGGAACGCGAGGGCACCTGCCTGCTGCTGGCCCCG
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GACGGGCTACGGGTGCTGGCCACCAACGCGTCGACCCGGCCCGGCCCATCCCTTTACCGAGGCGGGCAACAGC
GAATTCAACGCGTTGATCTGGATGCCGCGCACGCCGAACGAGCCGGTGACATCGTGCTCGTCTGACTCGACCAAC
TTCACGACGCTGTTCCGGCGGTCCGACAGCCTCAGAACTTCTGGCACAACCTGGCCACGATGAGGTGA

75% sequence identity to Gene 10 (SEQ ID NO:102)

CTGCGCGCGCTCAGCGGGGACGCGGGAACAGGATCTAGTGGTGGTGGCTTCCCTGGGATTGCTGGGCGAC
TTTCTCACCCTGCACAACGGCTACAGCACCTTGAAGAGCGGAGGGGGGCCAGGCGCCATTCCAGGGCCCC
CACTCCGACGTGCGCCGACATTGTGGAGGCCATCGCGGGCTCGTTGGTGAATTCCTGCGCACGACCTTGCCCTT
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CTGTTCCGACGACCGGATATTGGCCGACACCGACACCTGATGGTGTTCGGGCTGGTCTTCTCCCCGCCGAAGTC
GTGGCCGACGCGGGGAGAACTCGCGGATCGGAGCCAGGGTGGATCGCGTGGGCTCCAGCCTGCTCCTCGCCCG
CAGCAGGACGACGCGGCTCCGACGTCAAGCCCGACCGGGAGGACGATTAGCTGCACCTCGGGCATCGGCACGTC
CCCCCGCTACATCGGTTATCGGCCCTACACGGGCTCCCTGTTCAAGGCGCTGGACCTTGCCGTGCGCATCACGTG
GGGCTGCTTCCGGCGCCCCCTGGCCGCCACCGCTCTGATGGCTCCCTGAGCAGGTTTCGCGTCTCGAGGCGGCC
GCGGTCTGCAGTTGTCTCGACCTCAACATTGACCGGCAACTCCCCACTTCGACCTCACCCGCGGGTAAGG
GACGGCCTAGGGGAGCTGCCAGCCTACGGGTGGACGCGCGCGGCCCATCGCTATAGCGAGCCGGCAACTGC
GATTTCTACGGGTAGTTTACGATCCCGCGGCTCCCGTACGTGGCGCTGTCTCGAGCTGGTGTCTCCACGATC
TACAGGAGGCTGATCGGCAGATCCGACAGTTTCAAGATCTCCTAGCACTTCTGCCAGGATGAAGTGA

80% sequence identity to Gene 10 (SEQ ID NO:103)

CTGCCCCCGCACTCCGGCCGAGGGCCGATCTGCATGTACTGGACCTCGAGCAATGCGTGGGATTTCGCACCGCGAG
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CGCGTGCATCCGCCGGGGTGGCCGGGACGGGACAGTTGGCAGCGGTGAGCTGCTATCCCCACCTCGACGGGGCC
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GACCGGCTTCGCGTGCAGGCCACCGAACCCGTGCTCCCGCCCCCGCGCATGCCCTAACCGTGGCCGGCAACTGC
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85% sequence identity to Gene 10 (SEQ ID NO:104)

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CAGGTGCTGGCCGGCGAAGGAACCGGACAGGAGTCCGCGGTGATCCACCGCGTCGTCCAGGCCCGCTACCGGGTG
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CGGCGGCATCAACGGTTTTCCGCCAAGACCGGCTCGCTGATCAAGGGGCTCGACGTTCCGCTCCGCTTCAGCTGG
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CGGCTGCAGGACCATGTACCAACGCTGATCTTACCGGCTTCTGCCGCTCTACGAGCACACCGCCCCGCAACCG
GACGGCTACGGGTGGTGGGACACCTACGCCTCGACCGGGCGCGCCATCCATTACCGTGGCGGGCAAGAGC

Figure 4-1

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GAATACAACGGGTTGATGTGGAAGCCGCCGCTCGCCGTACGAGCCGGAGACATGGTGCACGTCCACTCGTCCATC
TTCACGACGAGTGGCGCGCTCCGACAGCATCAGAACTTCTGGCACATCCCGGCCACGATGAGGTGA

90% sequence identity to Gene 10 (SEQ ID NO:105)

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CACTGGGACGACGCCCACTATCTGCAGCGCATGGCCGGCACCTTCGAGCTATTCCACCGCTCGACGCTAGCGTTG
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GACGGGTAGGGGTGCAGGCCAGCCAACGCCCTGACCCGGCCGCCCCAACCCCTTACCGAGCCGGGCAACAGC
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95% sequence identity to Gene 10 (SEQ ID NO:106)

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GAATACAACGCGTTGATCTGGATCCCGCCGACGCCGATCGAGCCGGTGACATCGTGGTCTGCTCGACTCGACGAAC
TTCACGACGCTGTTCCGGCGGGTCCGACAGCCTCAGAACTTCTGGCACAACTGGCCACGATGAGGTGA

99% sequence identity to Gene 10 (SEQ ID NO:107)

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GAGGCCGAGCCCGGGGAGATCTCGGCCATCCGTGCTGGCTGGAACGCGAGGGCACCTGCCTGCTGCTGGCCCCG
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GGCTGCTGGACGATGTCACGACGCTGAACATTACCCGCTGCTGCCGACTACGAGCTCACCAGCCCCGAAAGC
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GAATTCAACGCGTTGATCTGCATGCCGCCGACGCCGAGAGCCGGTGACATCGTGGTCTGCTCGACTCGACCAAC
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Figure 4-2

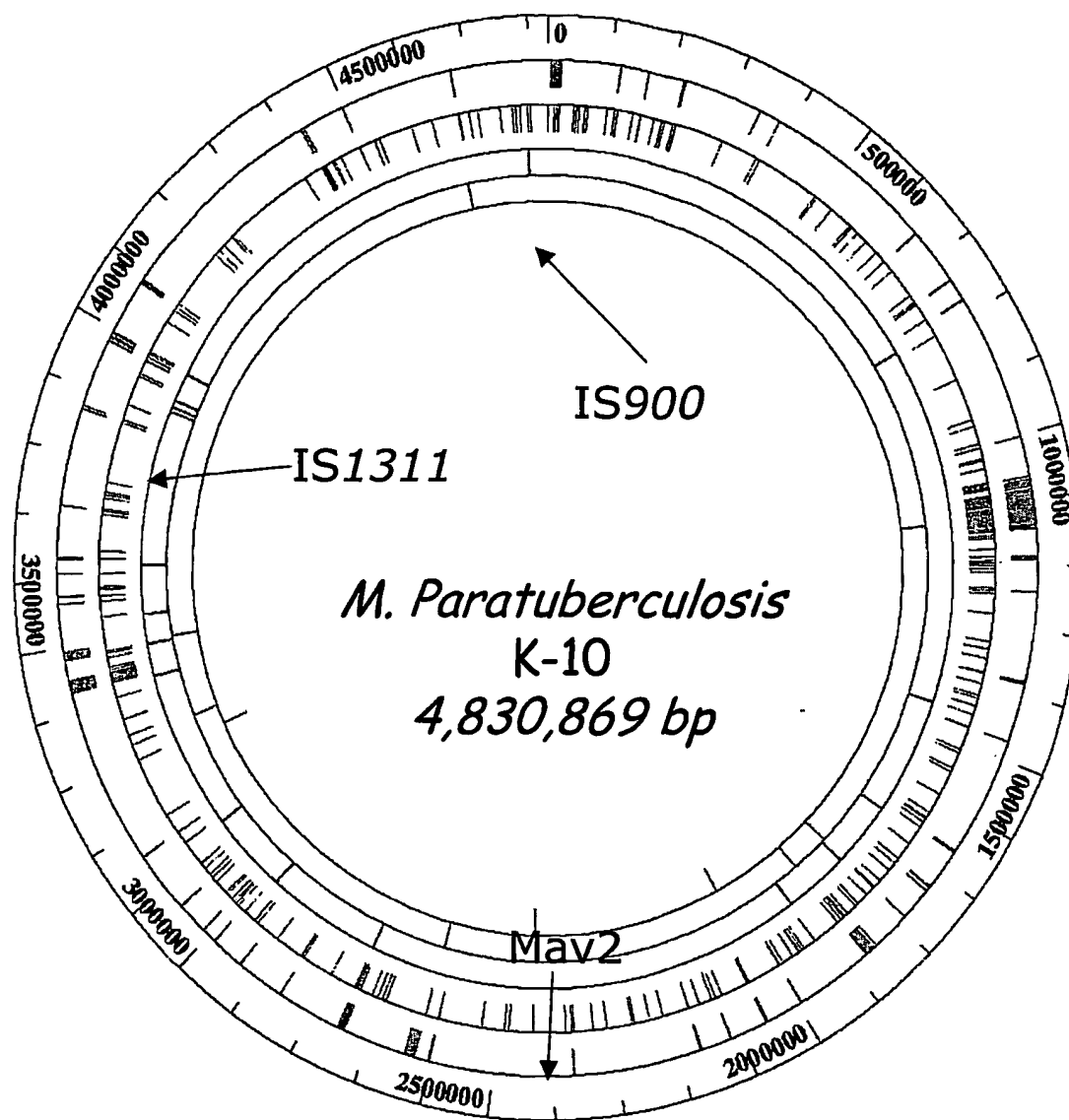


Figure 5

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Figure 6-1

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>Contig16_57
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Figure 6-2

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>paratb_68
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Figure 6-3

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Figure 6-4

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Figure 6-5

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>paratb_109
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>paratb_236
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>paratb_257
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Figure 6-6

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Figure 6-7

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>paratb_1107
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Figure 6-8

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Figure 6-9

Figure 6-10

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Figure 6-11

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Figure 6-12

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Figure 6-13

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Figure 6-14

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>paratb_5350
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Figure 6-15

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Figure 6-16

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>paratb_5419
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Figure 6-17

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>paratb_5432
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Figure 6-18

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CGCGCCCTCCGCCACGTTCCCGATCTAATACAAAGCACGTCACCGCCACCCAGGCGTGCGCG
>paratb_5447
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Figure 6-19

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Figure 6-20

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>paratb_5471
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Figure 6-21

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>paratb_5484
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Figure 6-22

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Figure 6-23

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Figure 6-24

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>paratb_5527
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Figure 6-25

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Figure 6-26

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>Contig16_5568
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Figure 6-27

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Figure 6-28

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Figure 6-29

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Figure 6-30

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Figure 6-31

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CACGACGTGCTCGATTCTTCGGGCCATCAGCTCCGAAAGCACTTGCTGTGAGGCAATTCCACCGAGG
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>parathb_5652
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>parathb_5653
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>Contig16_5657
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>parathb_5658
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>parathb_5660
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CGATGACAGCAACCGGGGTGCGCTTTTCGTCCATCGTCTGCTGAGCGGGTGGTGCACCTAT
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Figure 6-32

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>parath_5661
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CGGAGATGGACCGCTTGCAGGAGCTGTTTGCAGGAGGCCATGTCAGGGCATCGCTGCGCACGGAT
>parath_5662
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GGCGGGCGGTTCGGCGATGACGGCGCCGATCTGGATGGCTTCCCCGCCAGAAGTGCACCTCGGCGC
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>Contigl6_5665
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CGGTCGCGGCACCGCCGCCGGCGCCACGCCGAGCATCCCTCCGGCCATCGCCATGGCCCCGAC
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Figure 6-33

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>parath_5692
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Figure 6-34

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>parath_5709
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>Contig16_5922
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Figure 6-35

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>paratb_5923
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TCTTGTGACGGCGTGGTGAGCGCGACGATTGCGCGTCTTCTCGAAGGTGATGGGCCGTCC
>Contig16_5925
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ACAGGTGACGGGCCCGAGGCCGGGTGCTGAGGCGATGATGCCGCGCGGGTCCGGCTCGGCGTAG
>paratb_5926
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ACTCTTGGGCGGCGGTCAACAGCAGGGTGGCGTGTGGTTCGCGCCAGGCGCCGCGGGAGTGGCG
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GAGGTCGGCAAGGAAGTGGACTGGACCGCTACCGCGCGGCGACGGGTGTGTACGCCCCTCTGGG
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>paratb_5934
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Figure 6-36

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>parath_5942
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Figure 6-37

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>parath_5955
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>Contig16_5969
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GGAGGCGCCGCCGATCCCCGCGGCCCGCCGGTGGTGCCGGTCCCGGTGGTGGTCCCCGCCGGT
>parath_5973
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Figure 6-38

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>Contig16_6206
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Figure 6-39

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Figure 6-40

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Figure 6-41

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Figure 6-42

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Figure 6-43

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>paratb_8634
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>paratb_8635
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Figure 6-44

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>Contig16_8744
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>parab_8860
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>parab_8935
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>parab_9247
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Figure 6-45

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>Contig16_9248
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CCGACGGCGCTGAAGGTTACCGGCACCCGGTACAGCTCCGGCTCGCAGGCGGCGGGCACCCAGT

>Contig16_9249
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>Contig16_9250
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>paratb_9278
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>paratb_9283
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Figure 6-46

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>parath_9284
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CGTCTCGGGTCTTCGTTGGCGCATTTTCGACGCTCGGCTTGAGCGTGACCCAGCCGGTGTAC
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Figure 6-47

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>parath_9298
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>parath_9300
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>parath_9309
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Figure 6-48

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>paratb_9312
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GGTTGGCGCTCATATCCATCCAACCTTGACCGGACCGCCACCAGCGTCGAGTTTTCGCGGCGCAG
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>Contig16_9315
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Figure 6-49

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>paratb_9330
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>paratb_9331
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GCTCCAGGTGACGGCGCGTTTGTATGCTGAAGCCGAGGAGTTTGGCGAGCACGACAGCGGGCAGT
>paratb_9332
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CCACGGTGACGGCGCGTATCCGCGGCGCTGCTGTACGAGATCGGCGAGCAGGCGGTGACGCGG
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>paratb_9343
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Figure 6-50

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>paratb_9344
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>paratb_9347
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Figure 6-51

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>Contig16_9769
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Figure 6-52

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>Contig16_9969
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Figure 6-53

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>paratb_10275
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GCCATGAACCGCCGTCGGGTTTCAGCTGGTCGGTGCCTGCGACCATCATGTAGGTGGTGCCGT
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>paratb_10278
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>Contig16_10279
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Figure 6-54

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>paratb_10824
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Figure 6-55

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>paratb_10826
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>paratb_10828
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CCTGCATCCGGCCCCGGGTGGCCGCGACCGGTGAGATGGCACCCTGACCTGCTTTTCGCGACCTG
>paratb_11048
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>paratb_11166
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CGCGTTGTCTTATCCATCGGCTCCAATCTGGGGGACCGGTGGCGCGGCTGCAGTCCGTCTGTCG
>Contig16_11303
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Figure 6-56

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>paratb_11844
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>Contig16_12399
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GGTCTTGACTAACTGGTCGCCGATCCAGAACCGCAGCAGCTCACCCTCGACGTGGACATCGCAG
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Figure 6-57

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>paratb_13137
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Figure 6-58

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>paratb_13152
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>paratb_13153
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GCATCGGACGAAGAAATTGCGGTTCGATGAGGTTCGATGCCGAGTCGGTCGGCGTTATTAGTCGAC
>paratb_13154
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CGGGTAGCACCACATTTACGCGGCAGAAATGTGTTCCAACCTTGACCCCTACGGATTGTTCGG
>paratb_13155
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TAACGGCGGTATGCCCGCACGGAAGTTTCGCGATGATCTACGGACAACCTGGTGTGCGAAAGTCC
>paratb_13156
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CGCTCGCGGGGTGTATGTGGTGACCGTGGATACGATTGACGACGCCATCGCGGCGGCAACCGA
>paratb_13157
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>paratb_13168
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Figure 6-59

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>paratb_13169
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Figure 6-60

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>parath_13184
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>parath_13198
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TAAAGTCGTATGTGCCGACGTTGATCTCGGTGGCTCCGGCACCGTACGGAGCGAATGCGCGATT
>parath_13202
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Figure 6-61

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>paratb_13203
TCC TTGGAGACGGGTGGCGAAGTGACACGGATGTGTGCGCCGCTCGGGATGTCGTCGGGCGTCGGAGTC
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TTCGTGGCGTTGGTCATCCCTGAATCGTGACCCATGGGAACTCCTTCGACCGGAATTGGCAGAT

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CGCGTGAGCACAGGGATACGTGAGAGGGGTCGATGGTGACGGTCGAGGACTTGGGTGCGCCGTGC

>paratb_13205
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TTCGGTCTTGGCGGTTGAAGGGGGAGGGTCCGCCAGCGATCCGGGTGGGACGGCGCTTCGTTGGGAC
GCTGTGCAAGTGATGCATGGCTGGACGCACGACGGGAATCACGATTGGAAGCAGGATGATCGA

>paratb_13206
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>paratb_13207
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GCCGGCACATTCGGCCGGCGCCCTCTGGTCTCTGTCCGCCCGTCCGAGGTCCAGGCGTGGGCCGCTGA
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>paratb_13212
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Figure 6-62

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>paratb_13719
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>paratb_13721
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CGGATGTCGGCGTCGCCGAAAGACGGTGTGGTGGATCCCCAGCTGCAGGTGCACGGGGTGCCTG
>paratb_13723
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Figure 6-63

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>paratb_13733
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>paratb_13746
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Figure 6-64

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>paratb_13752
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CAGCAGCGCCACAACGACACTCGCACCGGTGGGAACGAGCAGCCGACGACGAACGCGACCGGG
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>Contig16_13755
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>paratb_13756
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CACGCCGTGCGCACGGCAGTACAGCAGCCCCGACGATCAGAAAACCGATCAGCGGCAAGCTTTCC
>paratb_13757
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Figure 6-65

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>Contig16_13766
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CGGCAACCGCCGGCCGGCCACCGGTTCCGTGCGCGCCACGGTGGTGAGGGCCGGCCGGCCGGTG
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Figure 6-66

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>paratb_14279
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>Contig16_14301
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>Contig16_14903
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>paratb_14930
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>paratb_14931
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GTGAAGCCACCCGGAACCGGCGAGCGTAGCGGTTTGATCACCGCGACATGGCCGGCGT

Figure 6-67

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>paratb_14934
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CACGCAATCGCGGGTTTCCCCGGATCGTCGTAATCATGGGCGCTGCAGTGGGCTTCGATCACCGCTGC
AGCGCCAGGGACTTCGCGGCGCACTCGTCGGATCGCGGCGATCAACTGCGTCACGGTGTCTCTG
>paratb_14935
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GCCAATACGTCAACGTCTGTCGAATGAAACGCGCCCGCCGTGATCGGCAACCCGCACGCTGCTTT
>paratb_14936
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>Contig16_15007
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>paratb_15059
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>paratb_15258
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Figure 6-68

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>Contig16_15305
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>paratb_15306
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CGGACCTTGCGGTTGCCGCGAGTGAGCCAGGCCATTGAGCGTTCACCATGGGCGGTTGTTGGC
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CGCCGGCCGGCTCACCCACCTTGTAGGTGGCCAGCGCCTTGGCCACCAGCGTGCCCTGCGGGT
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CGGGGCCGTGATCTTTCCGGTCTCAAGCAGCGGGCCAGGCGGCGAGCGGCCCGGCCGGCGGGCCCCG
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Figure 6-69

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>parath_15685
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ACGCCGCCTTCGCGGCCGCCGACGTGCAGATCCTCAACCAGGACGTCGGCGCCGCGTTTCGACCG
>parath_15783
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CGGCGCACCGCAGCCAGTTGTTTCCCGAGGAGATGTTTCGCGGACTTGTTCGCTCGCAGCGGGG
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>parath_15789
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Figure 6-70

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>Contig16_16838
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GTGTCCCGCGGGCACGGCTTCATCGTGGTGCACCGGCTGGACAACCTGCGCCGACGCGGGCGCA
>parath_17028
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GGCGGGGTGCGGGCGCGCGATGACGTTGCGGGTGATCTTCACGGCCTGCTGCAGCTCGCGCA
>parath_17153
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ACCGCGTTGACGACATAAGCTTGCCGGGTCACTCGGAAGGCCAGCCGCTTCGGTTACCAAAGCC
>parath_17154
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GCGCGGGTGAAGCTTGCCAGGGCGAAGAAATGCGCGCGCATCGACGGGTGCGCCTCGATGGTCA
>parath_17155
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ATTTTCGACGAGCACCTCGCCGTCGCGTCCGCTGACCAGTTCAGCGTTGTCCCGCAGTGGTTCCCGC
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>Contig16_17156
ACCTCGTCGATATCCGCGTTGAGTGAGTCGGCGATCAACCACACTTGTTCGGTGAAGATGGCGCTGTT
GAATGCCAGGAACGGTTGGTGTGCGGGCTGATGTGCGCGACGGGTGCCCCGAAACGCCATGTTGTGCG
AACGTGATCGACGTGCTCTCGTACGCCGACCAATCGGCGCGTTCTTGCAGGGTGATCTTGTGCA
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>parath_17163
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Figure 6-71

>Contig16_17164
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>Contig16_17165
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>parath_17166
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>parath_17167
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>parath_17168
GGCGGGAGTCTGTTTTCGGTATAGCTGGCACCTCAACCCAAGCCCCGGCCAACAGCGCAAAAGGTTGG
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ACATGCCCTGCCAGGTTTTTCGGTGCATTGCCCCGCACCAATCCGACTGCCGATAAAGCTGGCC
>parath_17169
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>Contig16_17174
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>Contig16_17175
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>Contig16_17176
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Figure 6-72

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>Contig16_17177
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CCGGGGAATGGTCATGTTCGATGACGGCGAAGACGTTGAAGTAGTCACCCCGCACC GCCCGGTCA
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AGGACGCCGACGAATTCGTGAGGCGCGTCAGCAGTTGGCGCACATCGGTCTCGTGCCCGGACA
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GGCGTCCCCGGGCCCCGGCGGCGGGCTGATCGCCCGGCGCCGGCTGGCGATCGTCGGGCAGCAGCAG
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>Contig16_17187
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GCGTCGGCCGGGATCGACACGTGGCGGTGACGTCGAGAATCAGCCTGGCCCGGCTGGGCTGCG
>parath_17188
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CGCACCCACGAGCAGACCGACCAACAGCGCGGTACCAGCAGCCGCTGCGCACGGTCATCGCG
>parath_17191
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>Contig16_17192
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>parath_17194
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GCACCTTCCCTCGGTTTGCTTTAGCCAGGGGTAGACCGCCGTGCGGCCCTGCAGATCGGTGACGCGGA
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Figure 6-73

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>paratb_17195
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>paratb_17196
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CGACGTTTTGCCAGCAGGGACTGCAGCGTTTGGCCCTGTCCCTGGAACACCTGTAGTAGCGCG
>Contig16_17197
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>Contig16_17198
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>paratb_17199
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>paratb_17200
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GCCGCCAACACCTCGAGCCCCGGCACCGGCGTGGGCGGCTGCAGCGCCAGCGGGAACATGCC
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>Contig16_17202
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CGGCGACCAACCGTGACCGGCACGGTTTGGGTGAAGCCGCCGCGAAACTGCGTGAGCGCGAGGGC
>paratb_17205
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ATACTGTTCAACACGAGAGTATCGTTCTACGCTGGCCACGGCTGAAGCCCACCGGAGGAGCAAT
>paratb_17207
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Figure 6-74

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>paratb_17208
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CCGAAGGAATTGCGCTACATCCTGTGAGCGTCAGGCCGCGGGTCTTCATCACCGCCGAGGGAT
>paratb_17209
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TTTGACGCGCTGCTCGAGGACGAACCGATGGACGCCACGGTGGCGACCGATCCCGCCAACCCGGCGGT
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GGCTCGGCGAGCACCGCGCGGCGTGTGCGTCTTAAGCCCGGTATGGCATGCCGACCATGGC
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CGCTGATCATGGGCTTTTCAAGAGCTGATTCCCCGCGTTGATGGCGGGCAATTCGGTGATCTTGCG
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CGACAAATGCGAGCAGTACGTGAAGTTGGCCGAAGAACACGGCGCAAGGTGTTCTGCGGTGGCGGAC
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Figure 6-75

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>paratb_17221
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ACGCGGTGCGCATCGCCAACGACAGCATCTACGGCCTGTCCGGGCAGGTGTACGGGACCGACGCGCG
GCCGCGCTGCAGGTGCGCGCCGACTGCGCACCGGCGCCGTCAACGTCAACACCACCGTCTTCT

>Contig16_17222
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>paratb_17223
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GGAGGAGTTCAGCCCCGAGCCGCTGTCTACTCCGAGATGCGCCCAGGCTGCTATGACGCCAAG

>paratb_17224
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CTGCGGCCAGCTATTCATGGAGGCCAGCGACCGCGAATTCGGGTTCGAGTGTCTGCAGCACTACAACG
ACTGGCTCGTCGAGGAATGGTGTGGTGCCGCCCCCGCGCTACATCCCGCTGATGCTGATCCC

>paratb_17225
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CGTTCTCGGAAAACCCGGAACCGTTGGGGCTGCCTACCATTACGACCCCGCGGGCTACTGGGAACCG
GTGATGGCCGCGGCCAACGAACCTCGAAATGGTGGCCAGCATGCACGTGCGTCTCTCGTCGACCC

>Contig16_17226
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ACGATGCTGTCTGGTTGTTTCAGCGGCATGTTCCAGCGCTACCCCAAGCTGAAGATCGCGCTGTCCGA
GGGTGAGGTGCGCTGGATGCCCTACTTCTTGAGCGCGCCGAACAGGTGCTGGACAAGCAGCGG

>Contig16_17227
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>Contig16_17230
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>paratb_17231
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GGCGGCGCCCTTCGGGATTTCGCGTCAACGCGATCTGCCCGGCGGCCATGCCGCTGACCGGTTTCATGG
CGGCGGGCGGGTGGAGGTGACGCGGAGCAGCAGGCGGCGATCGCCGAATCGGTTCGGGGTCA

>Contig16_17232
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>paratb_17233
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GCGTCTGCACGAGCTGACCGGCAGCACCGACACGATGTTCTTCCACGGGTGCCGTACCCGGAAGTGC
CCGATTTACGGTGTTCGACTACGACTCGTGCATGATCGCTTACCGCAATCCGGAGGTGTTTCG

Figure 6-76

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>paratb_17234
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AACGGCGAACAGCACAAGCGGTATCGCGCGTTGGTCCAGCCGTCGTTCCTGCCGGCGAATGGCAAGTG
GTGGATTGACAATTGGATCTCCGAGACCGTCGACCTGCTCATCGACGGACTGGTTACAGAGGGG
>paratb_17235
CGCGCCGAACCTCAACGTCGACTTCTGCGCGGCCATCCCGGTGCTGACCATCACCGGCAGCTTCGGCGT
GCCCCGTCGAGCAGGCCCTCGACATCCGCGAGGCGCTGGCGCGGGATCCGAGAAGGTGGTCGACCTGC
TCAAGCCGGTGATCGCCGCCCCGCCCCGAGGAGCCGCGCGACGACCTGATCAGCGTCCTCGTGCA
>paratb_17236
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TGCTGTTGCTCGGCGCGGGCTCGGGCACCACCTGGAAGCAGATGGGCACCACGCTGACGACGCTGTTG
CAGCGTCCCGAATCCTCGAGGCGGTGCGCGCGGACCGTTCGCTTTTGGCGCGGCGATCGAGG
>paratb_17237
AGGCGATCCGGTGGATGCCGACCGATCCGATGTTCTCCCGCTGGGTGATGGCCGATACCGAGCTGGCC
GGCGTGTGATCCCCGCCGGGTCTGTCTGTCACCTCGCGCTCGGGGCGGCCAACCGGGATCCCGCCCCG
CTGGGACCGTCCCGACGAATACGACATACCCGAAAGTTCAAGCCGTCGTTGGGTTTCGGGCGAG
>paratb_17238
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CGACCGGCTGCCCCAACCTGCGGCTGGATCCCGACGCCGAACCGCCCCGCTTCGTGGAATGTACGAGC
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>paratb_17241
ACCACGGCTAGCATTTCTTCGGTGTACGTGCTGAAGAACGGGCCGCGGAGCGGTGCGCGCGGCTGCA
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>Contig16_17242
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Figure 6-77

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>paratb_17249
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>paratb_17264
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TGCGCGATCAGGCCCTGGCGGTGGCGGGCGGCGCTGCGCGCGGCCGGCGCCGGCGCCGGGGACACCGTC
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>Contig16_17366
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CGCGGCCGTGCGGCGACCGCTTCCGCAGGATCCGCCGCCGCGCACAGCCGTCGCGGGCGCCAAAC
>Contig16_17403
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>paratb_17406
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>Contig16_17407
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>paratb_17409
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>paratb_17419
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>Contig16_17420
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Figure 6-78

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>paratb_17421
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GCAACATGTTGGGAGCGGGCACTCGAAACTTGCCTTTCACCAGATCCGCAGCACGTGCCGCGGC
>paratb_17422
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CCGTACAACGACTCCGGCTTGCCTCGACCGTGTCTCGTCGGGCTCGTAGTAGCCGGCCAGCACCT
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CGTCTCTGGGCCAACACCGATCCGAGTCGCGACTGCCCGGATGCAGCCATACTCGCTGTCTGAC
>paratb_17425
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Figure 6-79

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>paratb_17440
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Figure 6-80

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>paratb_17463
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Figure 6-81

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Figure 6-82

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>paratb_18193
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Figure 6-83

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Figure 6-84

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>paratb_19499
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>Contig16_19893
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Figure 6-85

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>paratb_19903
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Figure 6-86

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>paratb_19935
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Figure 6-87

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Figure 6-88

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>Contig16_20399
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CCTTCGGGCGGGCCGGTCACGCTGCACGGGACCGGGCCTGTCTAGCTCCAGCGATCTGAATTT
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>paratb_20401
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Figure 6-89

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>paratb_20410
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Figure 6-90

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>paratb_20423
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CGCACTACTAACCATTTTCGCGTGCGCCACAATAGTTCGATACGGGCGAAGCGCCAATGGCGACGCGC
GCGGGCGCAGTCTCAGGAGGGCTTCGGCGTTTCTCCCCGCGCTTGAGATTTCGGTTTCGAGTGAG

>paratb_20424
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CAACCCCCACTTCGGAGGGCCGATTGTCTAACCTACATACTAGTATGTATGCTGATCTCGACACCGCG
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>paratb_20425
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CAGCCCAGCGCAGAGCTTGTGGATCATCGACGCCTACACCCTCGTGTGGCCGATTACTACTG

>paratb_20426
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CATCGCCTCAGTGCTGTGCGCCCTCGCCGCATCGTCGGCCGAGCTGATTGCCGCACGCACCATTCAGG
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>paratb_20427
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>paratb_20428
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>paratb_20429
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>paratb_20430
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>paratb_20431
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>paratb_20432
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>paratb_20433
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>paratb_20434
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CCAACCTCGGTGCAACCCCTCAATCGCGCGATTACGGCATCCTGCAACTGATAGAAGCCTCCAC

>Contig16_20435
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GGTCAAAAAACCCAAGCAATCACAAACCAGCCCGATAAGCGAACGGCGGCACGGCCACGAGGACGAG
CTGTGCGGCGCGGCTGCCCCGAATCGGTTGCGGCCTACCAGAATGCCGTTGCCGCAGGGGATTTCG

Figure 6-91

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>Contig16_20436
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GTCGCCGAGATGGTGGTGCACTACAGCGCATCCTGCACCGCGACGGCGCGCCCTAGACAGCACCTTC
CACGAGACCTACCACGCCTACAACCCGGCGCTGCGGTTCTTGCTCGAGCGCCCCGTGCACGCGA
>paratb_20958
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>paratb_21004
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CCCCGCTGGCGCCGAGCCTGGCCCCGCCTAGCCTCGCCCCGCTGGCGCCGAGCGTGAACTAGGCG
CACGTTTCGGCGGCGAGCGTGAACTAACTTCACGCTCGCGCGGCGTTACGCTCGCCGCGGCGC
>Contig16_21065
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>Contig16_21164
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CGCCCGCGGAACGCGCGGCGCGCCCGCGAGCCGCGCGGTCTTTCCCGATCCGATCCAA
>paratb_21187
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>Contig16_21952
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>Contig16_22123
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ATGCCGGAGTTGCAGCGGCTGCAAGGCGATCCGAACGTGGAATTCATCGATCGGCTCGACACGC
>paratb_22127
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CGAGATCGACCGCACGGTGTGACCTGGCCCCAGCTCGCGTCGGACGTCTCTCGGTGCCGCG
>paratb_22130
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TATCAGTCGATGATCCGGCGCGAGACAAATCGCCATCACGGAAGCCCGGAGCGGTGACGCGCGGAC
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Figure 6-92

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>Contig16_22133
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CACCGCCGACCGCCGGCATCGGTGCCGAGCCGGCGCAGCGTCGAACGAACCCGGGTGCGCAAT

>Contig16_22134
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GGGCACATTGCCCCGCCCCGTTCCCCCGTTGAAGCTACGGTAATGGAAATGTCGGGCACGTTGGACTAC
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>Contig16_22143
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TCTGCTATCGCGGCCGCTGGACAGCGCCGCGATGGAGTCGCTTCTCGCCAGCGCGTCGTCCCCATGA
ATTTCTCCGAGACCGGGCCAGCGGTCTAGATCCGCCAAGAGCGCAGTACCCCCACGCTCACGGG

>paratb_22144
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CAGCGTCCAACCCGCGGTGAACCGCCGTTTCGATTTCGGCGCGATCGATGCCCGGCACGCCGAACCGGC
CCCCGGGAGGAAACGCGACGATGAACAGCCGTGCGTCGGGCGCCGCAACGGCGCTGACCTCCCC

>Contig16_22146
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CCAGGGGGTGAAGCCGACCCGGTAGAAGAACCGAATCGTGCGCGCCGTGAAGCCATAGCCGCA

>paratb_22147
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GTCAGCGCCGTCGTCTCACCATGGCCCTGATCGGCGCCGCGCGACCATGGTGAAGGGCACGGCCAGC
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>Contig16_22154
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>Contig16_22222
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>Contig16_22236
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GCCCGGTGCCGCCCCGCGGCGCCCGGACCGCCGAGCACACCGCCGGAGGAACGCACCGTCATCGTC
CCCGGCTCGCCGGCCCGATCGCGCGTCCGCCCGGCGAGCGCTCCGGCCGGGCCACCGCGGACAT

>paratb_22301
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CCCCGCGCCTACCCGTCCCCGGACCCGTTCGAGCCGTTTCGCCGTCGCCCGCGTGGAGTTGGCGAAGGA
GGGTCTGATCGTGTGGGCAAGGTGGTCGAGGGCACGCTGGCCGCCGACCTGAAGGTCGGCATG

>paratb_22479
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>paratb_22481
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ACCGGCGACGCGCGGTGATTGTGGCGATCGGTGCGCACCGATCCGCCAAGAGCTTGGCGTCCCCGG
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>paratb_22482
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TCACGACCTGGTCGGGCTCTTCGGCATGGCGGGCCAAAGCTGATGGAACCTCGCCGATGCCGGCAAGT
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Figure 6-93

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>parath_22483
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AGCCCAAGGGCACC CGGCGACAAGCTAATGGATCAGTGCTCAACGGCACGACACCCCATCAGTGCTAC
AGGAACCCTCACCAACCGGCCGGGGCGTGATCTAGCCTTAGAAGTCGGCCATCGCTTCAGCTGG
>Contig16_22616
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CCGGTCGACAGGTACGCACGCCGGCGGGGACGTCGAGCCCGAGCAGCGATCGCGGGGTGGTTCG
>Contig16_22619
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>Contig16_22663
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CCTGCCCCCGGCGAGCGTGAAATTAGCTTACGGTCGCGGCCGAGCGTGAAACTAACTTCACGC
>Contig16_22956
GGTTCGTTGATCGCGGGAGCGCTCGGGGTGGCCGCGGGCGGGCTTCGGCGCCGCGGTGGCGAGCGCGGA
TCCCCCGCCACCGCCGCGGGGCCCGGGGCGAGCCGTGGGGGCGGGCGGGCGGGCGGGCGGGTGGAC
CGGGTGGACCGCCCCCGCGCGGGGTGGACCGTGGGCCCGCCACCGGGCGGGCGGGCGGGGCC
>parath_23136
GCCGTGCTGATCACGCTGTCTGTCGAGGTGAAGCTGCCGTGCTGCTGGCACTGGGCTTCGTACGAT
GGCGCTGGCCTACCGGTGCGGGGGCAACCTGCGCGCGCTGCTGCTGGCCGGCGGCGCATGGCGGCGC
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>Contig16_23367
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>parath_23368
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CGTCATGGCAGCAGGTTCCGCCGCGGGCAGGCGCCGATGACCATGCCGATCTGGGCCGCCTTCC
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>parath_23371
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GGCGGCCCCACCCAGCTGAGCTGGTGGGTGACGCGGGTGCAGGAGGTGGCCAGGGCCATCAGCG
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CCAGCTCTCGTTCGGTCTGATCGCGCCCTTCATCCCCGCGCGGGGGCGCCGGGGGTGGCCGGG
>parath_23373
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CCCCGGCGCCGCGGGCATGCCGGCCACCGCACCGGCCCGGTGCGGACCACCCAGCCGCGCC
>Contig16_23375
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Figure 6-94

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>paratb_23461
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GAGACGGGTACAGACGGCGCGCTTGAGCTCGTCGACCTTGTTTCAGCTGCTCCAGGGCAGTTCTGA
>Contig16_23540
CGGCTCGCCGGCCCCACCGGGTCAGGGCGAGCACCGCGGCCTTGCGCACGTCCAGGTGCGCGTCGCCCCA
GCGCCTCGCCAGCAGCGGCACCGCGACCTCGGCGGCGCGCACCGGCCAGCGCCCGCGCGCGCCTTCG
CGCACCTGCCACGCGGACGCGCGCAGCGCCTGCGTGATGGCCCCGTAATCGTCTGGGCGCGCAGC
>Contig16_23733
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CCGCCCGAGCCCGCGCGGGGTACGGCCCCGCCACCGGGCTACGGCACGCCCGCGGGGTACGGCACGCC
ACCCCCGCGCGCGCGGGCTATGGCCCCGCCCGCGGCTACGGGGCACCCCCGCGCGGCTACGGC
>Contig16_23842
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ATCGTCCACCGACGCATGCTTTTTGGCAGTTTCGCGACGTGTGGATAACTGCGGCAGCTGAATGGGTAA
GGAGATGCGTCGGTCGCGGATTCCGGCCGAGGAGAAAACCCACCGTGCCACCCCGTTTTGCGA
>Contig16_23868
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>Contig16_23869
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>Contig16_23870
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>paratb_23908
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GCGGACGTCAAACCAACAGCAGGCAAAGGCTTTACGCCGACCCGATCATCGCCTACCGGCACA
>paratb_24003
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>Contig16_24155
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T

Figure 6-95